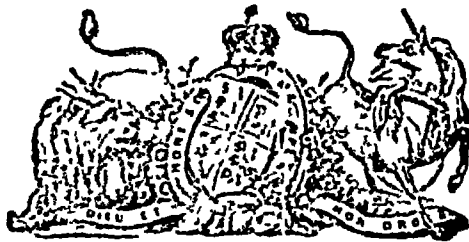




Department of Agriculture and Commerce,  
N.-W. Provinces and Oudh.

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IN THE  
NORTH-WEST PROVINCES.



PAPERS

RELATING TO THE

CONSTRUCTION OF WELLS  
FOR IRRIGATION

ROORKEE.

PRINTED AT THE THOMASON CIVIL ENGINEERING COLLEGE PRESS.

1883



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Executive Engineer, Department of Agriculture and Commerce
- 3 Note on the Moradabad Wells
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REPORT  
ON  
WELL IRRIGATION IN THE NORTH-WEST  
PROVINCES AND OUDH.

BY  
CAPTAIN CLIBBORN, B.S.C.,  
EXECUTIVE ENGINEER, ON SPECIAL DUTY WITH THE DEPARTMENT OF  
AGRICULTURE AND COMMERCE

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FROM

CAPTAIN J. CLIBBORN, B S C.,

*Executive Engineer.*

TO

THE DIRECTOR, DEPT AGRI AND COMMERCE,

NORTH-WESTERN PROVINCES AND OUDH

*Dated Nain Tal, 15th August, 1882.*

SIR,

I HAVE the honor to forward a Report on Irrigation from Wells as practised in these Provinces in compliance with your demi-official instructions

You will notice that the results I have arrived at, if correct, show that well irrigation is only profitable under favorable conditions, and there is reason to believe, that in most districts cultivators have already very fully availed themselves of their opportunities, leaving to us now only the doubtful sites to occupy, if we enter in an extended scheme.

There are, however, many opportunities for profitable Government interference in detached situations, and above all in the repair of existing works, to the financial success of which, however, the increase in cost due to the supervising establishment will prove a serious hindrance

Of all the districts I visited, Bulandshahr presents the most favorable conditions for well enterprise, but detailed enquiry is necessary I will forward the statistics of the worst villages in the pergannas noted in a few days

I had intended putting up a series of subsoil water contours with this Report, from which some hints on the causes of the variation in quantity of supply might be expected, but I regret that all the necessary information has not as yet arrived

I trust to be able to forward them to you in the course of a month

The recent advances in electricity may prove an unexpected means of famine protection in these Provinces, and the water power of the canal falls could not be better employed, than in lifting water, either from the rivers, for those tracts where wells are impossible, or from wells with a good supply

From the Note on the Moradabad Wells, it must not be supposed that it is impossible to build wells giving a good supply in pure sand, it is only a matter of expense, if the well rested on a platform of concrete of thickness and area sufficient to support it over the inevitable hollow in the sand below, we would have an admirable imitation of the mota, which should be perfectly successful, the cost, however, of laying such a platform, say 20 feet below water surface, would be considerable, and the necessary area is yet a matter of theory

I have the honor to be,

SIR,

Your obedient Servant,

JOHN CLIBBORN, CAPT, B S C,

*Executive Engineer*





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# IRRIGATION FROM WELLS IN THE NORTH-WESTERN PROVINCES AND OUDH.

## INTRODUCTION.

The importance of well irrigation

1. Irrigation from wells has been practised in these Provinces from time immemorial. The subject is one in which Government takes great interest, and justly so, as the area watered is large, and such irrigation in many districts constitutes the only means of bringing a high class crop to maturity.

Increase desirable.

2. There are vast inequalities in the distribution of well irrigation, even in districts in which there is an equal demand for water, and the question which naturally suggests itself to all interested in agricultural improvements is, why not increase the number of wells until districts requiring water have a full command of it?

Information necessary.

3. To answer the above satisfactorily, it is necessary to investigate the following points —

1st The available supply of water.

2nd " " labor

3rd The cost of irrigation.

4th The area commanded per unit.

The unit selected.

4 The necessity for information on the first three points is self-evident—it is important to know the fourth, as without it we cannot determine the number of wells required for a given area. And it may be here explained that the unit selected is one pair of cattle or men employed actually lifting water.

Cost variable.

5 The cost of irrigating a given area depends on a number of factors—such as depth to water surface, amount and kind of labor employed, situation and crop. For instance, wheat in Muttra requires five waterings, in Moradabad only one, gram is rarely watered more than once, while tobacco often takes ten waterings, and the depth of water given to different crops also varies greatly.

Existing statistics useless.

6 Abundant statistics regarding well irrigation exist, but unfortunately they are of little value in the present instance, as the area irrigated has nearly always been returned per well, and a well is not invariably one unit, but often contains as many as 8, indeed there are instances of wells containing 16 to 20 units.

Ditto ditto.

7 In many examples on which calculations have been founded, irrigable areas were returned as irrigated, and wells which failed to give any useful supply in ordinary years were counted on as capable of a high duty in famine time.

Former experiments insufficient,

8 Again with reference to the quantity of water lifted per day, the experiments have usually been carried on for a short period only, and the day's work calculated by multiplying the result by an assumed number of hours representing the day's work.

and misleading.

9 This method is inaccurate and misleading, for the rate of work on every well, as might naturally be supposed, varies greatly during the day, with the condition of the cattle, the men, and the depth of water. It is always dangerous to calculate large results from small percentages, nor is it unlikely that the Assamī will be interested in the result, and attempt deception, which need only be carried on for a short time, and will not seriously interfere with his day's work.

Experiments how made.

10 For the above-mentioned reasons, I determined that the only way to arrive at a just conclusion on the subject of well irrigation was to experiment for the full working day on all classes of wells over a large area, and also to record, personally, as far as possible actual areas irrigated, number of times each crop is watered, and all other details bearing on the subject.

Scope of observations.

11. The Report now submitted gives the result of these experiments, which were carried out in 20 districts of the North-Western Provinces and Oudh, over a distance of 1,200 miles, at intervals averaging 10 miles apart, the line of country covered is shown on Plate IX, and it will be seen that it embraces every class of well irrigation, from the first class Kili lifts of Aligarh to the percolation wells of Bundelkhand, and the Dhenkhi irrigation of the semi-Tera tracts \*

\* Vide Table A.



## THE SUPPLY OF WATER AVAILABLE FOR IRRIGATION FROM WELLS.

### The water bearing strata

12 The sub-soil water supply in the Gogra-Ganges Doab is, as far as is known, inexhaustible, and nearly everywhere it is at a reasonable distance from the ground surface, but irrigation decreases in a marked manner when the depth to water surface exceeds 60 feet. The water-bearing stratum as a rule is sand, which in most instances is overlaid at varying distances from the ground surface by a bed of clay, indurated sand, or kunkur, called variously "mota," "matbarowa," or "nagasan."

### Indurated sand and kunkur beds local.

13 The existence of the indurated sand and kunkur beds is obviously due to local action since the Doab was first formed, they are met with in but a few isolated localities, and have little bearing on the general question.

### The mota.

14 Far different is the case with the clay bed or mota. Where it occurs, wells are always possible, and there are few Zemindars or Assamies in any village who cannot point out with accuracy the site and depth of the layer.

### When deposited.

15 The mota was deposited at the period of the formation of the Doab, and in conjunction with the sand strata, was probably the result of action similar to that which now produces clay beds in the khadirs of deltaic rivers.

### Not universal

16 The mota is not universal, its general distribution is shown in *Plate III*, and there are only a few isolated villages even in the best districts in which it is found everywhere.

### General distribution

17 Referring to *Plate III*, it will be noticed that the mota is not known at all in those tracts directly underlying the hills, and gradually increases in occurrence as the slope of country decreases, it is, however, much more prevalent in the Ganges-Jumna Doab than in the Ganges-Gogra Doab.

### All clay not mota.

18 The term mota is not applied to all clay strata, but only to those either underlying or directly overlying sand containing water, there are often many such strata of varying thickness and at different depths.

### Situation known to cultivators

19 Canals are only a recent introduction compared with wells, which in many districts have been the only means of raising high class crops for a naturally stable community. The accurate knowledge which villagers generally possess of the position of the mota is not, therefore, to be wondered at. It is not universal as might be supposed, but when a cultivator asserts his knowledge it may generally be accepted.

### from experience

20 Their information is of course derived from experience gained in excavating for wells, which have either proved failures, or have been filled up or broken long since. In many cases the memory of the former well has been lost, and I have come across several instances in which new wells have struck on old and long forgotten ones, the sites having been chosen on a tradition of the existence of the mota.

It is curious to note that although the mota may be scarce in a village, if it exists at all the inhabited site will be found on or near it, so placed for obvious reasons, and perhaps the mota may have had more influence on the selection of the sites for great native towns than it is generally given credit for. Amroha and Bareilly may be instanced.

### Sub soil sections

21 Sections A to G (*Fig 1, Plate I*) illustrate various conditions of sub-soil found in the Doab, they might be indefinitely multiplied, as the clay, sand and water occupy every possible relative position.

### Spring wells.

22 Leaving out of the question for the present wells which receive a supply from percolation, we will consider the case of what are usually termed spring ("Bom") wells, which should be sunk so as to have the curb or lower ring firmly embedded in the mota, thereby (if a masonry well) shutting out from direct entry all water overlying it. Now the generally accepted theory regarding the use of the mota for water supply is that it acts as an artesian basin, and that the supply entering the well through an orifice which is bored in the clay is a veritable spring,\* caused by the pressure of water from the collecting area of the basin.

\* Such wells are termed spring in the Tables to distinguish them from percolation wells.

Artesian action unlikely

23 The facts which are alleged to support this theory are *first*, that until the mota is reached the water supply is easily exhausted. This is contradicted by experience. *Secondly*, that when the hole is bored into the mota a copious supply of water enters the well, often causing danger to the workmen if they do not escape quickly, and sometimes rising above the mouth. But the artesian theory pre-supposes the comparative continuity of the mota, which is at variance with the universal testimony of cultivators, and the facts alleged are easily explained on other grounds, *vide* paras 26-30. It will also be shown that artesian action is quite incompatible with the strata of the Doab.

Sub-soil water contours desirable

21 Although the ground surface of these Provinces has been thoroughly surveyed, and numerous cross sections taken of the ground levels, unfortunately there has been but little systematic attempt to contour the sub-soil water surface, for which, in conjunction with the ground surface levels, we possess unrivalled facilities in the numerous wells, and it is certainly desirable that in future surveys the sub-soil water and the position of the mota should be measured and recorded in a similar manner to the ground surface.

The curve usually shown by a Doab Cross Section

25 *Plate IV* shows the sub-soil water and ground surfaces on a section taken across the Deoband Doab along the Shamli road, and may be taken as a type. The water surface is at its highest in the centre of the Doab, and gradually falls in a rapidly increasing slope as it nears the rivers on both sides. The longitudinal slope is one corresponding in some degree to that of the country, and over the whole area in which the so-called spring wells exist, it does not exceed 1 to 2 feet per mile. There is abundant evidence that the water from the high land drains into the rivers on each side at a slope of about 1 in 100, or 50 feet per mile, (it varies according to the nature of the stratum,) and even if the mota were uniformly continuous and regularly overlaid the water-bearing strata, (which it does not,) it is evident that there could be very slight, if any, artesian action. A type section of the mota as it really occurs is shown in *Fig 2, Plate I*.

\* Mr. Beresford's theory of supply

26 The following theory, advanced by Mr J S Beresford, Executive Engineer, Irrigation Department, appears to offer a true solution of the action which takes place.

It is admitted that in new wells when the hole through the mota is first made, a certain quantity of sand is forced up into the well with the water, but after a short time this emission of sand ceases, and if the mota is a good one (3 to 5 feet thick of hard clay) no sinking of the well takes place. A hollow in the sand beneath must, therefore, be formed, and Mr Beresford assumes that it is of the form (C) shown in *Fig 3, Plate I*, and that the mota merely acts as a platform to support the well over this hollow in the sand, which gives a surface large enough to discharge a supply corresponding to the head given.

The "Head"

27 The head is the difference of level between the water inside and outside the well, for when water is drawn from a well the surface reduces more or less rapidly according to the quantity drawn out and the strength of the supply, and at length a point is reached when the water vacuum is just sufficient to draw in a supply equal to the quantity taken out. This is the mean head, it naturally varies a good deal over the Doab, and can be found for any of the experimental wells by deducting the figures in column 67 from those in column 66, Table A.

Artificial imitation of the mota

28 This theory is well supported by facts familiar to Engineers experienced in laying foundations below water surface on sand, where these consist of a platform resembling the mota. If any flaws exist, after a slight primary emission of sand, nothing but clear water is discharged, and no damage to the foundation occurs, provided the platform is thick and strong enough to act as a beam over the hollow in the sand below. The size of the hollow will be modified by two conditions —

- 1 The head, which regulates the quantity of discharge
- 2 The comparative fineness of the sand, which regulates the rate of discharge

The coarser the sand the smaller will be the hollow. Perhaps the best idea of the area required to admit of the delivery of a given quantity of water in a given time may be obtained if we represent the spaces between the particles of sand by the holes in fine wire gauze of varying gauges. Coarse netting will require a smaller area to admit of a given discharge than fine netting.

Action of land springs.

29 Similar action may be observed by any one curious enough to examine the *true springs* when the sub-soil water escapes at the junction of the bangar and khadir. On the

banks of our large rivers the khadir from A to D will usually be covered with a clay deposit over sand, and the springs burst out at A, *Fig 4, Plate I*, and flow into swamps between A and D, or to the river direct. A sort of cup or hollow is formed, *see B*, in which the sand bubbles up with the force of the spring, but when the area of the surface of the hollow is large enough to discharge the water supply, nothing but the very finest sand is carried away.

Result of drawing water from a well resting on fine sand

30 If a well rests on sand alone when water is drawn, abstraction of sand takes place from below, and the well being a heavy body sinks into the hollow. The effect of drawing water from a well in pure sand is to drain an inverted cone, the height of which is represented by the depth of the well below water surface, the steepness of the sides varying directly with the fineness of the sand stratum, *Fig 5, Plate I*.

It will be seen that the content of the cone increases with the depth of the well below the percolation level.

The water nearest the well is first drawn into it, and passing vertically down close outside, draws the sand with it into the well, and if the process is continued long enough, the sand will eventually rise into the well until nearly level with the water outside \*

Wells possible in very coarse sand or gravel.

31. The results described will only occur when the quantity of water drawn from a well is greater than the surface exposed, i.e., the area of the bottom of well can deliver. There are wells on the margins of the Bundelkhand lakes which give an ample supply from fine gravel, and which correspond in every point with the example above described, except that the intervals between the particles are greater.

Wells in fine sand possible but expensive

32 There is no difficulty in designing a well which would work successfully in pure sand of any fineness, it is only necessary to make it large enough, but the expense in the strata usually met with in the Doab would be enormous, and as far as practical irrigation is concerned it is out of the question.

Wells resting on pure sand are constantly used for drinking purposes without any injury to their stability.

Advantage of the resistance sand offers to flow of water

33 For the ordinary cylinder well it is therefore evident that the existence of the mota is a necessity for its success† as an irrigating medium, and it is worth noting that but for this very resistance which sand offers to the passage of water, irrigation wells would practically be impossible in the Doab, for the sub-soil supply would drain away to the lowest point, its contour would be a nearly level line between great rivers, and the depth to water on the watershed, which is now the least at the tablelands, would be a maximum.

Variation in quantity of supply

34 There are great variations in the quantity of water capable of being drawn from wells close together and apparently similar in all respects, but the explanation is simple enough when we remember that the area of the mota must have a similar effect to an increase in the depth of the well in enlarging the diameter, and consequently the content of the drainage area (*vide Fig 6, Plate I*).

Percolation wells when used

35 Percolation wells are used under the following conditions —

- (a) When the mota does not exist
- (b) When it does exist but is at such a depth below water surface that it is too expensive or too difficult for the people, with their existing means to reach it
- (c) When wells resting on the mota become injured from various causes.
- (d) When they pay better than mota wells. Water enters a percolation well by filtration from the sand, either through crevices in the wall of the well, or through a grass or twig lining, which admits the water while holding the sand back. Such wells are generally found in the khadirs and low-lying lands, where recent diluvial action has washed away the former strata, replacing them by nearly pure sand. On the outskirts of the town of Jalalpur, (Shahjahanpur District,) there is a curious instance of this action. For miles round, the Ramganga, which is a great wanderer,

\* *Vide Moradabad well experiment*

† Natural or artificial

has cut away the old strata and the mota is unknown, except where a kunkur stratum exists in a small patch of 16 acres in extent, which is crowded with no less than 14 kucha wells, some of them 100 years old—all worked with Rātis, a class of lift not much used elsewhere in the pargana. Percolation wells are also extensively scattered over the districts lying under the hills, where, as before noted, the mota is rarely found, and as (in common with the khadir) such lands require little water compared with the more southern districts, there appears to exist a sort of balance of power regarding the facilities for irrigation in the various tracts of the Doáb.

With reference to the four conditions under which percolation wells are used, *Case (a)* is self-evident, *Case (d)* will be dealt with when the cost of irrigation is considered

*Case (b)* occurs—

- 1st In villages, most parts of which possess a good mota easily obtainable, but certain other areas have the mota either at a greater depth or overlaid with quicksand, and the people, accustomed as a rule to dig wells with facility, magnify to themselves the difficulties to be met with in these isolated areas, which, in less favored villages, would be considered serviceable
- 2nd When the mota is at such a depth that the Capital outlay would leave no margin for profit
- 3rd In areas where the mota is overlaid with sand formerly dry, in which kucha "Dom" wells were the rule, but where now, from a rise in water level, the sand has become saturated, and the people are unable to reach the mota simply because they cannot dig through the wet sand. In the 1st and 3rd cases the advantage of Government interference is obvious, advice and regulated advances would be invaluable

*Case (c)* occurs—

- 1st When the mota is thin. If the well is overworked the supply of water will increase, but so will the hollow under the clay, and eventually becoming too large for the thickness of the mota, the well drops through and is practically ruined. This occurs frequently in *famine years*, when good wells are strained to the utmost. Fortunately there is often a second layer some distance below, and were advice and assistance afforded, many pitiable examples of wasted capital could again be made profitable

Cultivators are frequently well aware of this danger, and will refuse to allow a second *churru* to be used, although apparently the supply in the well is ample

- 2nd When the well gets broken below, and the owner is afraid to clear it out and re-open the mota. These cases are quite remediable in most instances, but often are beyond the powers of the owners.
- 3rd When through carelessness the well is allowed to get filled with débris and a small supply only filters through. This is scarcely a case of enforced percolation, and occurs mostly in those canal-irrigated villages, when the water surface has been so much raised that such a well will suffice for the irrigation of a small plot of opium or garden produce\*. In cases like this it would appear advantageous to reserve the canal supply for less favored localities
- 4th When the sub-soil water falls below the mota. This does not invariably result in the well becoming percolation. Often as before mentioned a second mota exists, and if it can be reached the well may be underpinned, and a fresh supply obtained from the lower layer, for its stability is in no way endangered as it rests on the mota above. If, however, no lower mota exists, or if it is at a great distance, the cultivator can only dig a hole in the sand below, line it with grass and obtain a small and intermittent supply, the end is generally the destruction of the well, as the mota is gradu-

---

\* Cultivators in canal villages often keep up a sort of home farm round the well to employ their cattle on, and opium is a favorite crop, as it requires frequent and thin waterings.

ally undermined, from the abstraction of the sand by the bucket, and it has also lost the support given by the water formerly below it

#### Sources of supply

36 It is somewhat difficult to understand how the rain water, which naturally must be the main source of the sub-soil supply, finds its way below the surface. Experiments made after heavy falls on plateaus show that the depth to which water penetrates directly into the soil is not great, it varies from a few inches to as many feet according to the nature and level of the surface, and from the sub-soil water contours we see that the rivers even in heavy flood can have little or no effect\*. Practically what we want to determine is the source of the supply in the higher levels, *see*, AA of any Doab cross section, *Fig 7*, as these must be nearest the source, the lower levels clearly being the result of slow drainage towards the rivers on either side. That this drainage is very slow is both certain and fortunate; certain, because we know that the level in wells even in years of excessive drought falls a few feet only compared with the great difference of level which exists between the surface of the water at the centre and the edges of the Doab, for instance, in the section of the Deoband Doab before referred to, the difference of level is 16 feet in a distance of  $1\frac{1}{2}$  miles, which is a comparatively flat slope, but we have no record of any fall in wells near this approaching 16 feet. The resistance to drainage is fortunate, as without it the contour would assume the direction of the dotted line CC, (*Fig 7, Plate I*), which in many districts would be fatal to the interests of well irrigation. That the rainfall does not filter evenly down from the whole surface exposed may be accepted as evident, but there are great variations in the nature of soils, and any cursory inspection of a map will show the watershed intersected with hills and hollows, the majority of which undoubtedly have clay beds, but in many the soil is more or less porous.

#### Sources local

37 This assumption of local and isolated filter beds is supported by the fact that the rise of water in wells is most marked in some villages, while there is scarcely any yearly variation in others, and in all the water usually resumes its normal level by the end of the cold weather.

#### Bhogpur wells

38 A good example of the effect of the water in tanks on wells is found in the Bhogpur village, Cawnpore District, the plan of which (*Plate VII*) shows a marked variation in depth according to the positions of the wells with reference to the various village tanks.

#### Normal level

39 It has been noted that the sub-soil water will practically stand at a slope of 1 in 100, but it must be remembered that this is when it has an outlet, even though the quantity discharged may be small, if no escape is possible and the supply is cut off, the surface must assume a much flatter slope in time.

#### Water surface high in sandy tracts.

40 Accepting this theory of local sources of supply, we ought to find a high surface level in sandy tracts indifferently supplied with the mota, and the Hasanpur pargana of the Moradabad District is a good example, as there the water level is found at 10 to 15 feet from the surface.

#### Supply from hill rainfall small.

41 The rivers taking their rise from springs near the hills and the Terai streams carry off a fair share of the rainfall which has been absorbed by the hills. The nearer tracts may be partly fed by the hill rainfall, but it is difficult to imagine the great length of the Doab to be supplied from such a source, it indeed appears impossible, when we remember the way in which the Doab is cut up by deep streams often heading the drainage.

#### Enquiry into local sources needed

42 The Doab rainfall must, therefore, be credited with the natural supply of sub-soil water above the mean level of streams, and an enquiry is much to be desired into the local sources of supply, the amount of water held in suspension, and the curves which it assumes under different conditions.

#### Artificial sources of supply

43 The artificial supply is obtained mainly from canals, it is, however, local. Permanent sections of the canal are rapidly silt-lined, which forms a good watertight medium, and great attention has for some years been given to fixing gradients which will avoid either erosion or heavy deposits. When percolation occurs, the distance is limited by the abrupt slope which the water assumes, and the amount by the fact that canals are usually carried along the watershed where the sub-soil surface is highest, *see Fig 8, Plate I and Plates V and VI*.

\* In the Deoband Doab the sub soil contour is 5 feet higher in the centre than the maximum flood level in the rivers on either side, and higher up every Doab the excess is much greater.

**The Agra Canal.**

44. The Agra Canal affords a good example of this action, the water surface has been raised in a gradually decreasing amount as the distance from the canal increases, and at an average distance of half a mile the influence is unfelt

The local supply from Canals compared with rainfall small

45 That the influence of the canal in raising sub-soil level is small compared with rainfall is well shown by a section, *Plate VI*, prepared by Mr W Willcocks, Executive Engineer, in 1879, which was a year of excessive rainfall, while 1877, also shown, was a year of drought, in which the canal was constantly run with a full supply The section was taken along the Meerut and Ghaziabad road, which runs nearly parallel to the canal and drainage lines, and is therefore no guide, unfortunately, to the transverse slope of the sub-soil water surface

Swamps how formed.

46 Swamps are formed by percolation from canals when the level of the ground surface intercepts the line of water slope, and also when the slope is flattened by an intercepting bed of clay, in both instances puddling the bed would be a more efficient remedy than drainage, which increases the quantity of the water percolated, *Fig. 9, Plate I*.

Abnormal fall in water surface a great injury to masonry wells

47 Drought, as might be expected, has a marked influence on the sub-soil water level in tracts of extended well irrigation when there is no artificial supply

In some parts of the Muttra District the fall in water surface amounts to from 15 to 16 feet during the last five years, and it has injured a number of wells, as in some instances the water has fallen below the mota

There is a possibility that the marked and, as far as irrigation wells are concerned, destructive fall of water surface in the Muttra District, has been partially caused by over drainage in the Aligarh District A glance at the Map will show that the parts of the Aligarh District which have been most effectually drained, were probably the local collecting areas which kept up the sub-soil surface in the tracts now suffering in Muttra, where there are comparatively few jhils, and the fall occurred just about the period at which the drainage system was perfected

A satisfactory explanation of this, and other interesting matters relating to the sub-soil supply, can only be obtained by carefully observed sub-soil water contours, and the subject of a complete Map of the North-West and Oudh water levels has been brought to the notice of Col Forbes, the Chief Engineer for Irrigation, and has received his approval as far as the preliminary arrangements are concerned

How repaired in Muttra.

48 The Assamies have repaired some wells in an ingenious manner by underpinning the masonry with a wooden or a grass lining An interesting example of this is No 6618, village Bheema, pargana Mahaban, *Fig 10, Plate I*

Two-lift well, old Water surface has fallen 12 feet during last 5 years For 4 years the well was kept at work with a grass lining, last year a wooden lining was put in This well cost Rs 400, and though built with lime, is now showing signs of giving way The present supply is percolating through the sides of wooden lining or *Lothi*

Where most observable

49 The following accounts of the abnormal permanent fall of sub-soil water level were supplied by Assamis in the field, and in all cases the fall had caused injury to the wells—

District	Pargana	Village	Fall in feet
Aligarh, . .	Hathras, . .	Sasni, ..	6
" . .	" . .	Hathras, . .	4
" ..	Iglas, . .	Iglas, . .	6 to 8
Muttra, ..	Saadabad, ...	Munsia, . .	6
" ...	Mahaban, ..	Mirhoul, .	a few feet
" ..	" . .	Raya, . .	15
Shahjahanpur, .	Pawaane, . .	Dharmangatpur,	5
Unao, ..	Unao, ..	Unao,	a few feet

Bundelkhand supply

50 In Bundelkhand the sub-soil is not uniform as in the Doab, the mota is unknown, and supply varies greatly according to locality, both in quantity and depth below the surface of the ground

**Soils.**

51. The soils of Bundelkhand and their characteristics are well known, they consist of "mar," "kabur," "parwa," and "rakar." Mar usually overlies the parwa and rakar, the exposure of the surface of which is supposed to be the result of denudation. In the more northern tracts of Hamirpur the direct rainfall appears to be the source of the sub-soil water supply, which has a better chance of filtering down than in the Doab, owing to the undulating nature of the country.

**No mota**

52. The absence of the mota overlying sand charged with water, deprives Hamirpur of the ample supply generally obtainable in the Doab. But there are local spots where a very good supply is obtainable, and nearly all the large villages have a fair area of garden cultivation which is irrigated.

**Surface level generally high on village sites.**

53. The depth to water surface is usually less on the inhabited sites than in the village "har," or outlying cultivation, (Fig 11, Plate II.) and this is explained by the fact that the villages are always from choice placed on parwa soil. Mar being considered feverish and rakar bad for cultivation. Denudation of mar, of which parwa is commonly the result, would naturally take place first from the highest points of the general surface of the country; the village will, therefore, usually be on a relatively high point of the sandy or water-bearing strata, and consequently near the water.

**Rapid fall in water surface after the rains**

54. Although after the rains and during the cold weather the supply is fairly plentiful, yet in many places by the beginning of the hot season it becomes much reduced, and wells frequently dry up. This appears to be due to the coarser nature of the soil, which permits of purely percolation wells being used, *vide* para 31, but the water can also assume a much flatter slope to the drainage on either side. Deep wells would appear to be the only remedy, but the point to which they should be sunk must be locally fixed, as the water falls below the beds even of the drainages in many instances.

**Rock wells**

55. In the southern parts of Hamirpur rock wells are common, the overlying strata are soft and dry, and the wells are sunk into the solid rock, the water gradually increasing in quantity with the depth. The supply is always precarious, and seems to be derived by percolation from fissures in the apparently solid rock.

**Artificial supply from lakes.**

56. The Bundelkhand lakes are caused by obstructions placed across the natural drainage outlets, where the slope and conformation of the country is suitable for the formation of reservoirs. Direct irrigation is practised from many of them, but is precarious, being dependent on the previous rainfall. Nor is it practised with that economy which the known limitation of the supply and the cost of artificially raising it should enforce.

The beds of these lakes are porous, often owing to the proximity of the hills, much mixed with gravel, and the supply spreads freely through the strata surrounding the lake, and it is here we find the best well irrigation in Bundelkhand. Even when the lakes dry there often remains hidden under the surface a copious supply which is distributed by the cultivators on the most economical principles.

Owing to the short depths to water surface and the coarse nature of the soil, wells can be cheaply built, and the cost of lifting is small.

**Canals from lakes not economical.**

57. The question of entirely stopping direct irrigation from these lakes is certainly worthy of consideration. The area capable of being irrigated would *certainly* be much increased from the enforced economy, and it is probable that the sub-soil supply would outlast even two years of drought if the lakes were not reduced by directly drawing water from them.

**Increase in number of lakes desirable**

58. Even small lakes scattered over the country would be of the greatest benefit, and the capital saved by the omission of the canals might be devoted to the assistance of the Zemindars in building wells, on which a rate could be charged sufficient to cover the outlay.

## VARIOUS METHODS OF LIFTING WATER.

### Cattle lifts.

59 In the Districts examined, except in a few isolated instances, cattle are only employed on what are called the "Kili" and "Lagor" systems, in both of which the *churrus*, or leather bag, is drawn up filled with water by a strong rope fastened to a wood or iron ring, round which the edge of the *churrus* is tied, the rope is carried over a pulley fixed on a framework overhanging the well mouth, and the cattle travel up and down an earthen ramp, sloped at an angle varying from 5 to 20 degrees. The *churrus*, or *pur*, as it is often called, when emptied by a man standing at the mouth of the well is again lowered down into the water and refilled.

### Lagor

60 When working Lagor there is only one ramp or slope, and when the *pur* is emptied the bullocks turn round and walk up the slope with the rope still attached to the yoke.

### Kili

61 The term Kili is derived from *kil*, a nail or peg of wood, and when cattle are worked in this system, as soon as the *pur* is empty the driver takes out the peg which fastens the rope to the yoke, and holding the end of the rope in his hands, allows the weight of the *pur* to draw him up the ramp A (see Fig 12, Plate II). The bullocks walk up a second parallel ramp B, to a feeding trough C, fixed near the top of the working ramp, and as soon as the *pur* is re-filled are again ready for work.

### Advantages of Kili

62 The advantages of Kili working over Lagor are that it does not harass the bullocks, it is easier on the driver, and it enables a number of cattle to be used at the same time, thereby saving delay and expense. Any one who has observed cattle worked Lagor will be well aware of the irritation caused by the jerks their necks get when the empty *pur* is thrown back into the well, nor do they get any food when working. It is easier on the driver, as he gets pulled up the ramp, and it saves time and expense, since two to four pairs of cattle can be employed at the same time, each pair waiting their turn. When the cattle are well trained only one driver is necessary, as the food near the well attracts them. The driver goes up the ramp much quicker than cattle do, and therefore more work is done in the time, one pair being always ready to lift. In both systems the driver usually sits on the rope going down.

### Distribution of Kili and Lagor

63 The distribution of the Kili and Lagor systems is shown in Plate VIII, it is curious that it should be so local, but except on the boundaries, the systems are absolutely un-mixed, and this although the great advantages of Kili working are admitted by most cultivators who know it.

### Content of lifts

64 The capacities of the various lifts are given in Table F, and it is interesting to note the difference in content. Lagor lifts vary from 150 cubic feet in Hamirpur to 570 cubic feet in Farukhabad, and Kili from 270 in Bynor to 765 in Muttra. The latter weighs, filled with water, no less than 500 lbs, and requires very powerful cattle.

### No. of units employed.

65 At Kili wells the same cattle are employed throughout the working day, but at Lagor, when more than one pair is used, the change is made at noon, and it is rare to find more than two pairs used. At Kili, however, three pairs are not uncommon, and for sugar cultivation four pairs are often used, the reason of this is that the cattle are employed crushing sugarcane up to the last day to which the Assams can put off getting in their sugar, when all combine to water the area, which is never large compared with the rabi irrigation.

### Minor economies

66 Besides the main divisions into Kili and Lagor, there are many minor differences in the manner in which wells are worked, some of which have a considerable bearing on the expenses.

In a single *pur* well with one pair of cattle three persons are employed—one driving, one emptying the *pur*, and one in the field adjusting the depth of the supply and clearing the



water-courses. In cases when an Assami's family work with him, his wife empties the *pur* and one of the children attends to the fields.

When two lifts in the same well are used there is at once an economy, for it only requires at most two persons more, and so on for any number of lifts added, as one man is quite sufficient to attend in the fields to more water than any well could supply.

But various other economies can be practised. If the ramps are parallel and the pulleys on the same side of the well, one man can empty two *purs*, or one man can drive two pairs of cattle even at Lagor, but these unfortunately cannot be practised together, as there would be a loss of time in emptying if the lifts came up together.

For two lifts on the same side a large well is required, and we therefore usually see this system employed in four *pur* masonry or in good kucha wells.

The following table shows the number of persons required to work different classes of wells under the best conditions —

No of Lifts.	One <i>pur</i>				Two <i>pur</i>				Three <i>pur</i>				Four <i>pur</i>				Six <i>pur</i> .				Eight <i>pur</i> .			
	Pairs of cattle per <i>pur</i>																							
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Kūh,	..	3	3	3	3	5	5	5	5	7	7	7	7	7	7	7	10	10	10	10	13	13	13	13
Lagor,	.	3	3	.	3	5	5		7	7			7	7			10	10			13	13		.

#### Advantage of large wells.

67 The economy of large wells and Kūh in this respect is manifest, for the eight *pur* well with four pairs to each *pur* should be equal to 32 one *pur* wells, which would require 96 men, but as will be shown further on when the number of pairs on one *pur* is unduly increased their efficiency is diminished.

#### Well fittings

68 The fittings of wells are very simple, they vary much, however, in different districts. The two main types are shown in Fig 13, Plate II. A is used mainly for kucha and B for masonry wells.

#### Their cost.

69. These fittings rarely cost any actual cash. The wood is generally the cultivator's own, and the making and repair is included in his general contract with the village carpenter. What he has really to pay for are the pulley, the material for rope, which is itself home made, and the *churru* or *pur* with its ring.

The cost of the fittings and lifts for each well is given in Table A, columns 44, 47; they are of necessity in a few cases approximate, but as a rule have been placed at the lowest possible figure, and represent as nearly as can be actual outlay.

The cost of the pulley and ring is included in capital, but the *pur* and rope are renewed yearly in fully worked wells. The cost varies as follows —

<i>Churru</i> or <i>pur</i> ,	Rs 3 to Rs 9	according to size
Ring for <i>churru</i> ,	As 2 to „ 1-4	„ to size and material
Rope „	„ 8 to „ 2	„ length and quality
Wheel „	„ 2 to „ 3	„ quality

#### Cattle and cost of food

70 The value of the cattle employed varies from Rs 10 to Rs 60 per head, and their quality has an important influence on the quantity of water drawn daily. An average rate of 3 annas per pair has been charged as the cost of feeding bullocks when working, this is less than the actual cost in the case of large bullocks, and perhaps slightly more than incurred for inferior classes. But good bullocks will work more days in the month than bad ones, and some small expense for food is necessary even on idle days. No addition to capital has been made to cover the purchase of cattle, it is certainly doubtful whether they are ever purchased directly for irrigation, and the rate charged is intended to cover not only the food, but also the interest on share of original purchase money and depreciation.

## Human labor and how employed

71. Human labor is employed in four ways for lifting water in the districts examined—

- 1st—As cattle Lagor—drawing with a *churru*.  
 2nd— " " " a *gurrah* or earthen pot.  
 3rd—The "Dhenkli."  
 4th—The "Râti"

Lagor with *churru*

72 (1) is common in Lucknow, Hardoi, Shahjahanpur, 10 men being employed according to the depth of the well and the size of the lift. As in cattle-worked wells, one man is in the field, one emptying the *churru*, and two-thirds of the balance pulling the rope, one-third resting.

I have never seen wells worked with more than one *churru* in this manner, the content of the lifts used is small, from 1.5 to 2.5 cubic feet, but coolies work much faster and for a longer time during the day than cattle.

The cost of fitting is similar to that for Lagor wells.

Lagor with *gurrah*

73. (2) I have only seen in Unao, one to two men are used pulling on the rope, one emptying and one in the field. This method is employed either when cultivators are very poor and cannot afford any more expensive arrangement, or when the supply is scanty and at a distance of 20 feet or more from the ground surface.

It is most expensive, the cost of two persons in attendance being often incurred on one man drawing water. Changes from one class of work to another are, however, frequently made, which somewhat increases the quantity of work done.

The cost for fittings is very small.

## Dhenklies

74 (3) Dhenklies are well known, they are universal in the East, and consist of a lever, the short end of which is loaded so as to a little more than counterbalance the weight of the rope and empty earthen pot on the long end. One man is employed lifting and emptying and one person in the field, and they change work occasionally.

It will be seen that the man working the Dhenkli has to pull slightly on the rope to lower the *gurrah* into the well, but when raising he has to exert less force than the quantity of water lifted would require, and neglecting the friction on the axis, there is no loss due to dead weight if the loading is properly adjusted. When the supply admits of it, two Dhenklies in one well are common, and thus the labor of one person is saved. 10 to 15 Dhenklies are often seen in different wells close together lifting into a common water-course, this usually occurs when a good local supply near the surface is available, and it is a most economical system of irrigation.

The cost for fittings is small—two uprights of wood or earth are used to support the axis of the lever, which is a 20 to 30 feet pole, the length varying with the depth of the well. When such long poles are not obtainable in one piece two are joined. Re 1 for first cost and 8 annas for repairs during the season, will cover the expense of a single lift.

## The Râti

75 (4) The Râti or *charli* (Fig 14, Plate II) consists of a rope passing over a light pulley fixed in a framework over the well, the rope has an earthen pot attached to each end, and the man working pulls them alternately up and down. As with the Dhenkli there is no loss due to dead weight lifted, and this class of lift is employed in similar circumstances, but its range is much more limited. The cost for a Râti is as follows—

Pulley,	...	..	Re 0-14-0, lasts 5 years.
Uprights,	...	.	" 0-2-0 " " "
Rope and <i>gurrahs</i> ,	...	..	" 0-4-0 to 0-8-0, lasts 1 year.
Total,			<u>1-8-0</u>

## Dhenklies and Râtis when used, and their economy

76 Dhenklies and Râtis are used as a rule in cases where the sub-soil consists of pure sand, or strata such as only give a small and intermittent supply, and when the depth to water surface does not exceed 20 feet.

The wells in which they are used are nearly always *kucha*, and if lined, only with a mat or rope of grass, which just suffices to hold the sand back and to keep the cavity in the centre open enough to allow the small *gurrah* to be filled. The quantity of water drawn is so

small, that the surface even in pure sand percolation wells is often not sensibly lowered, so that when the sub-soil surface is met with, at say 10 feet from the ground level, the Dhenkli continues drawing water at from 11 to 12 feet during the day. This influences in a marked degree the actual cost of irrigation, and when time is not an object, it appears difficult to improve on the Dhenkli in such a situation. If the supply is so bad that even the slow abstraction by the Dhenkli exhausts it, the Assami is equal to the occasion, for he halves the expense by only employing one man at the well, who alternately draws water for a short time, and then distributes it by opening the compartments in the field, thus allowing time for the supply to accumulate in the well.

Rates charged for human labor

77 In calculating the cost of irrigation, the rates for the men employed have been entered in the case of hired labor at those actually paid, these vary according to the situation of the village with reference to large towns, and from other causes, such as relationship, age and class. They have been obtained by careful enquiry. In some cases cash payments are made, in others only food and clothes are given, the latter have been worked out at current rates. Home labor has been charged at one anna per head per working day, deducting one man from the total number employed. This represents the cost of food and clothes, and although it is possible for a man to live on less, yet the labor is severe, and the allowance can hardly be considered excessive.

Work done.

78 Table F shows the work done with the different classes of lifts. It will be seen that in the case of cattle it increases in quantity with the depth of the well, or in other words with the continuity of the labor. It does not vary with men, as they can turn quickly, and in the case of cattle is reduced when the number of bullocks is unduly increased.

The gross work done by one man equals half ton lifted one foot in one minute for cattle the amount varies from a half to 3 tons per head according to quality of cattle and depth to water.

The Râti most economical

79 The Râti is the most efficient and economical lift for all depths up to 20 feet, but men unused to it do not like the labor, and the quantity lifted is small, and it is therefore unsuitable for thirsty tracts, nor is simple coolie labor always available in quantity. Cattle form the staple labor of the country, and it is therefore with reference to them that the question needs most enquiry.

A continuous motion the most economical for cattle.

80 A continuous motion giving the best results, the natural conclusion is that the cattle should walk round the well, but to make the motion continuous with the ordinary intermittent lift, necessitates such a complication of fittings and ropes, that the gain is more than compensated for by the increased expense and loss of time in adjustments. The chain pump has now been brought to a high state of efficiency at the Cawnpore farm, and it is to it that we must look for the most economical distributions of water from wells in quantity.

The chain pump

81. A continuous motion can be given to the chain of the pump from the bullocks walking round the well by simply lengthening and carrying it round a horizontal drum revolved directly by the bullock pole, the chain being guided by a pair of small wheels tangential to the circumference of the drum, *Fig 15, Plate II*.

The whole arrangement would not cost more than Rs 20 over the first cost of the pump.

A pump and fittings complete fit for a pair of cattle could probably be supplied from the farm for Rs 100, and the interest on this at 6 per cent would not be equal to the yearly charge incurred by Assamis for their lifts, viz, Rs 3 to Rs 12.

There is some uncertainty as to the maximum speed at which chain pumps may be safely worked. If it is found desirable to increase the speed, the apparatus above described can be easily adapted by adding a second driving wheel, and taking off the power with a chain, see *Fig 16, Plate II*.

## THE CONSTRUCTION OF WELLS.

By cultivation advantageous.

82. The cost of wells when constructed by cultivators has been given in Table A., and the great advantages of home construction by men, so much interested in the result, and so well acquainted with local facilities, need not be further remarked on. When I mentioned the subject of well construction to zemindars and cultivators, they always expressed a wish to do the work themselves, provided the necessary advance could be had on simple terms

Taccavi advances.

83. Their dislike to the present taccavi system must be strongly founded when the difference between the Government rate of interest and that charged for Mahajan's advances is considered, a curious instance of their dislike to taccavi on any terms occurred in Aligarh, for though the advance was offered without any interest to the cultivators of the land thrown out of canal irrigation in the Secunder Rao Tehsil, it was frequently, if not invariably, refused. The wells were built, however, and irrigation carried on, and it is possible that the absence of an advance was not much felt, as cultivators in canal villages are generally well off

Cost of Establishment will be heavy

84. If wells are built by Government they will have to bear the cost of the supervising establishment, which will be heavy, as the work is necessarily a good deal scattered, and small isolated works cost relatively more in this respect than large ones

Indirect charges

85. The following are the indirect charges which will be incurred in any extended scheme of well construction by Government agency —

Establishment,	20 per cent on works,	} this is according to Government of India orders founded on experience
Leave and Pension,	20 per cent on 85 per cent of establishment,	
Interest during construction,	at 4 per cent	

Total cost.

86. The total of these amounts to 27·4 per cent on works without considering the case of wells, in the construction of which exceptional difficulty is met with, it may fairly be assumed that an ordinary well to the mota, including all contingencies, can be sunk complete for Rs 36 5 per 100 cubic feet of masonry.

This figure represents—

Actual masonry,	Rs 25 per 100 cubic feet
Sinking, ..	25 per cent of cost of masonry
Earthwork, ..	5 " " "
Curb, ..	10 " " "
Contingencies, ..	6 " " "

Cost of fittings

87. This does not include the cost of fittings, which it is presumed the cultivator will supply himself. In the Table of relative cost, these items are separately shown to allow of a comparison with the rates worked to by the people themselves

Estimate low.

88. The prices fixed above have been kept down to the point at which it is only possible to do the work. They will require the most careful supervision to avoid excess, and allow nothing for unexpected difficulties

TABLE I—Relative Cost of Wells if constructed by Government.

Masonry well on mofa.	Depth to water surface.	CONSTRUCTION.			Interest at 6 per cent.	RATE PER ACRE.		Fittings.	ANNUAL.		Annual charge per acre for fittings and lifts.	Total charge per acre.	Remarks.
		Works.	Indirect.	Total.		Area irrigated in the year.	Charge per acre.		Lifts.	Total.			
1-Lift, ..	10	117	33	150	9'0	11 0	0 8	5/-	8/-	8'3	0 8	1 6	1-Lift wells— 4 feet inside diameter 1 foot thickness of cylinder 10 feet below water surface
	15	146	40	186	11'16	10 75	1 0	...	...	8 3	0 8	1 8	
	20	175	48	223	13 38	10'5	1'2	...	9/-	9 3	0'9	2 1	
	25	204	56	260	15 6	10 25	1 5	...	..	9 3	0 9	2 4	
	30	234	64	298	17'88	10 0	1'8	...	10/-	10 3	1 0	2 8	2-Lift wells— 6 5 feet inside diameter 1 foot thickness of cylinder 12 feet below water surface
	40	292	80	372	22 32	9 0	2 5	..	11/-	11'3	1 2	3 7	
	50	351	96	447	26 82	8 5	3 2	...	...	11 3	1 4	4 6	
	60	410	112	522	31 32	8 0	3 9	..	12/-	12 3	1 6	5 5	
2-Lift, ..	10	189	52	241	14 46	22'0	0 6	9/-	16/-	16 6	0 8	1 4	3-Lift wells not economical
	15	232	64	296	17 76	21 5	0 8	...	.	16 6	0 8	1 6	
	20	275	75	350	21 0	21'0	1 0	..	18/-	18 6	0 9	1'9	4-Lift wells— 8 5 feet internal diameter. 1 5 feet thickness of cylinder 15 feet below water surface
	25	317	87	404	24 24	20 5	1'2	...	...	18 6	0 9	2 1	
	30	360	99	459	27 54	20 0	1'4	...	20/-	20 6	1 0	2 4	
	40	446	122	568	34 08	18 0	1'9	...	...	20 6	1 1	3 0	
	50	532	146	678	40 68	17 0	2 4	...	22/-	22 6	1 3	3 7	
	60	618	170	788	47 28	16 0	3 0	..	...	22 6	1 4	4 4	
4-Lift, ..	10	429	117	546	32 76	44 0	0 7	15/-	32/-	33 0	0 8	1'5	Lifts Kih, one unit each The areas are deduced from Muttra and Aligarh maxi- mum-areas which are the best substantiated They are double the Lago areas of Rai Bareilly, which has the highest percentage of irrigation in the Province; see Appendix IV.
	15	514	140	654	38 24	43 0	0 9	..	..	33 0	0 8	1'7	
	20	600	164	764	45 84	42 0	1 1	...	36/-	37 0	0 9	2 0	
	25	686	188	874	52 44	41 0	1 3	...	..	37 0	0'9	2 2	
	30	772	212	984	59 04	40 0	1 5	..	40/-	41 0	1 0	2 5	
	40	943	260	1,203	72 18	36 0	2 0	..	..	41'0	1'2	3 2	
	50	1,113	307	1,420	85 2	34 0	2 5	..	44/-	45 0	1'3	3 8	
	60	1,284	350	1,634	98 04	32 0	3 0	.	...	45 0	1 4	4 4	

4-lift wells the best.

90 The uniformity of the results shown were somewhat unexpected, for there does not appear to be any great saving in one class over another, but as shown in the note on "various methods of lifting," there is a great saving in the cost of drawing water when 2 lifts are worked together at the same side of a well, the 4-lift wells are, therefore, the best as far as regards the cost of delivering water from a well. The diameters given in the table are the minimum used for the number of lifts, and are only just large enough for full sized *purs*, it would be an advantage to increase them slightly all round in practice

Increased depth of water.

91 The depths below water surface, i.e., 10 feet for 1-lift to 15 feet for 4-lift are relatively increased, as an increased head is required to supply a number of lifts in the same well

Cost of fittings

92 The cost of fittings has been thrown on the cultivators, it would be far better for Government to incur the increase of capital, and fix good stone uprights and platforms on each well. This cost would be repaid by the stimulus given to early irrigation, as often at first combinations are difficult, and no one Assami will care to go to the expense of fitting up a well, the benefits of which he will only partially enjoy

Cost of lifts

93. The cost of the rope and *churrus* will of course fall on the actual irrigator

Interest charges

94. Advances for productive Public Works are now made by the Government of India at 4 per cent, the interest on Capital has, therefore, been charged at 6 per cent, to allow for unforeseen charges, preliminary operations, settlement, &c

Dry brick wells

95 Dry brick wells have not been estimated, as where they are built, kucha wells are nearly always possible, and the lining is used merely as a means of protecting them from the wash of the bucket, a matter which should be encouraged as much as possible, but which scarcely calls for direct Government interference, as the expense is usually small Percolation dry brick wells cannot be recommended When the supply is near the surface the Dhenki and Râti are a much cheaper means of lifting water than a *churrus* from a surface lowered to obtain the head which is required by the latter, and when the depth to sub-soil surface is great, it will be found that the increase in cost of lifting due to a small and intermittent supply, will render them more a source of loss than profit to the Assami, and they fail utterly in very dry years unless carried to such a depth as to render their cost prohibitive

The profit on expensive wells doubtful

96 The cost of a masonry well depends directly on the depth of the true mota, this may be great even though the sub-soil water surface is high, in such cases and in instances when special means, such as pipes, &c, are used, the Revenue officer alone can tell whether the transaction will be a paying one or not, and that within wide limits, as the final result both as regards expenditure and success is always doubtful.

Bricks

97 The best description of brick to use for wells depends on the mortar, if this is good, large voussoirs may be employed for the cylinders, but when the quality of the lime is doubtful, small country bricks are to be preferred, plenty of water should be used, and a long time given to the work to set

Percolation into water-courses

98 A matter intimately connected with the construction of wells is the loss due to percolation from water-courses This seriously interferes with the success of large wells. From Abstract Table C it appears that the mean loss is about two cubic feet per foot run, during a day of 9 hours, and that the loss of area varies from 30 to 50 per cent per well for a water-course 500 feet long Some experiments recently made by Mr Beresford on the Anupshahr Branch, Ganges Canal, showed out of a total supply of one cubic foot per second a loss of 0.5 cubic foot per second in a distance of 1.5 miles, the soil being sandy for one mile, this for a day of 9 hours = 2.0 cubic feet per foot run, and the results shown may, therefore, be assumed as fairly correct

Can be prevented

99 This loss can be entirely obviated if the channels are lined with an impermeable material, and if pipes or concrete are used the cost will amount to about Rs 10 per 100 running feet

Cost of masonry channels

100 The maximum annual area irrigable by a 4-lift well at 30 feet to water surface is shown as 60 acres The best disposition of this area will, I think, be a parallel strip with the well in the centre on elevated ground, and this is not an uncommon arrangement of area for large wells, and suits the natural lie of the country, as the channel will be on the watershed with the irrigable area gently sloping on both sides

The width *ab* (*Fig 17, Plate II.*) should depend on the nature of the soil, but if for a 4-lift well we assume it at 400 feet, we find the length of permanent water-course required will be  $\frac{34 \times 43560}{400}$  feet = 800 feet = 3,000 feet, which at Rs 10 per 100 = Rs 300, and even assuming that it only saves one cubic foot per foot run, the amount spent will more than cover the cost of construction of a well capable of supplying 3,000 cubic feet per day, and entirely save the cost of re-lifting the actual water. It would, therefore, appear advantageous to adopt permanent channels to all wells built by Government. The cost will vary from 50 per cent. of direct construction in the case of low lifts, to 12 per cent. for a depth of 60 feet, or near 10 per cent. per foot of rise in water surface, and thus will also tend to equalize the rate per acre to be charged.

A rate of Rs. 2 per acre necessary to cover cost of construction.

101. Taking all contingencies into consideration, a round rate of Rs 2 per acre annual irrigation appears to be the mean charge required to cover outlay.

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## COST OF WELL IRRIGATION

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Cost variable.

102 There are few wells to be found in the Doab from which irrigation is carried on under precisely similar circumstances. Climate affects the number and depth of the waterings given, and there are marked variations in the characteristics of the cultivators, cattle, wells and methods of lifting water.

Estimate possible

103 The one advantage we possess in attempting an estimate of the cost is, that each individual well or cluster of wells is a fixture in its own plot of land, the boundary of which can be determined with reference to surrounding wells, and the maximum quantity of water which can be lifted in a day.

Division of cost.

104 Every crop that is watered from a well bears a cost over a dry crop, the total of which is made up from three main heads, viz —

- A Interest on capital
- B Annual charges
- C Cost of lifting the quantity of water required

Dry crops

105 The word dry is intended to refer to crops raised in lands unprovided with wells, as even when owing to the necessary quantity of rain having fallen, well lands are not watered, they have still to bear the yearly interest charges

### *A —Interest on Capital*

Interest.

106 The capital invested is the necessary cost of construction of the well with its fittings, and this varies from Rs 2 to Rs 1,000 with the class of well and advantages of the situation

The cost and description of the different kinds of wells and fittings met with in the Doab have been already given, and the detail of those examined will be found in Table A., columns 44 and 45. It was impossible to ascertain with accuracy the cost of very old wells, and even in the case of those recently built, it is difficult to fix the exact expenditure, both home materials and labor are used, the construction is often spread over a long period, and few Zemindars keep accounts, but a fair idea can usually be formed from a due consideration of the difficulties met with, the facilities for obtaining material, and the relative cost of similar wells, the expenditure on which is known. When no other means were available the sum was fixed at about one-half of what it would cost Government to build such a well.

In Table G the interest at 5 per cent of the cost of the experimental wells is distributed on the area actually irrigated during the year—both rabi and kharif. In many instances there was no kharif irrigation, in others it was difficult to ascertain correctly. When such was the case one-half of the rabi was added for kharif to make up the yearly irrigation, and the incidence of the rate is shown on this area.

Rabi irrigation

107 The rabi area is made up of crops which require a different quantity of water at various intervals, the maximum rabi area which can be watered, therefore, depends on the quantity of water raised and the crops grown.

Periods of crop growth

108 Table D shows the periods of crop growth for the districts examined. It is compiled from the famine replies, and the mean number of waterings and intervals between waterings entered were collected from personal enquiry.

Intervals between waterings

109 The intervals multiplied by the waterings do not always fit in exactly with the length of time the crop is shown in the ground, but this is only to be expected, as the waterings shown are those required in years when the cold weather rainfall is deficient, and the intervals the maximum the crop will remain uninjured without water.



Percentage of crops irrigated

110. The wells experimented on were, as far as could be managed, the best in each village visited, and the line of country was chosen so as to bring every class under examination, and Table B shows the actual area irrigated by crops per well, lift, and pair of cattle or man employed lifting water. The mean area and the percentages of crops for each district are shown, and also over each crop area the actual statement of the Assam regarding the number of waterings required is given.

Days required per watering

111. Table F shows the number of days required per pair of cattle or man actually lifting water to irrigate an acre at three different depths of watering, and by division, or addition, of these depths, the number of days required for any given depth can be readily obtained.

Depth of waterings

112. The mean depth of watering given in each district per crop is shown in Table B, and the same reduced by the loss from absorption in water-courses in Abstract Table C.

Information in Tables

113. We have, therefore, for each well, village and district a close approximation to, if not actual

Depth of watering in feet,  
Number of waterings required,  
Working days to the acre,  
Intervals between waterings,  
Percentage of crops grown and periods of growth,

and it is then a simple calculation to determine the maximum area which can be irrigated of any fixed proportion of crops, or of the percentage suitable to the district in which the well is situated.

The cost by Districts and lifts

114. Table II shows a final result for districts. The figures for those in which there were a large number of experiments are naturally most to be depended on, and fortunately this occurs in the best irrigating districts.

The rabi irrigating season

115. A reference to the abstract of Table D will show that, rejecting carrots, potatoes and tobacco, and making due allowance for ripening, the average time available for watering the rabi may be fixed at 180 days, but except in the case of wells on which a large number of cultivators per lift work jointly, this period must be considerably reduced. The same cattle cannot be worked more than 20 days in the month at such severe labor without serious injury, indeed this is the period generally given by cultivators themselves as a maximum, nor will any except the best wells stand such a constant strain. It will be safe however, to assume 150 working days as available, as few wells have less than two cultivators working at them. When potatoes, tobacco and carrots are grown this period is often exceeded, but wells which take 150 days to water their rabi crop area may be considered as fully worked, and from Table G we find that the mean interest rate on cost of construction per acre on  $\frac{1}{2}$  of the maximum rabi area is Rs. 4 for Muttra, when the depth to water surface is great, viz., 60 feet, and the wells are nearly all masonry, and Rs. 1-8-0 for the other districts, with a mean depth to water surface of 30 feet and all classes of wells.

Assumed maximum not reached in practice

116. Only one fifth of the wells examined attained their assumed maximum rabi area; the figure cannot, therefore, have been fixed too low, many had no kharif irrigation, and in only two did it exceed the allowance made of half the rabi area, the actual rate per acre in 1881-83 must, therefore, in the majority of cases have been far above the figures given.

Wells with no rabi irrigation

117. Some wells have no rabi area. Kucha wells are dug in both Bundelkhand and Rohilkhand solely for sugarcane irrigation, which is often watered when other crops are grown dry.

Number of wells or units required for a given area

118. A considerable difference of opinion exists as to the total area which should be allotted to each well, or rather to each unit (*see para 4*). We find in Table H the mean yearly command for each district per unit, but even in the most closely cultivated tracts of the Doab there is fallow, or land not cultivated in either the kharif or rabi of the same year, so that, even were the whole cultivated area yearly irrigated, which it is not, we could not get the number of units required by dividing the total area by the unit area. It will be seen also (*vide Table C*) that there is a serious loss of water when taken a long

distance, and cultivators are fully aware of this,\* yet the disconnection of the tracts of mota and the mixture of good and bad land in many places necessitates either the isolation of the irrigation, or the carriage of the water for a long distance, in which case the available unit area would perhaps not be worked up to.

#### Sample cases

119 With reference to the proportion of cultivated land which is yearly irrigated, I had hoped, but have not had time, to give some examples showing the allotment of irrigated and dry crops in certain type villages over a series of years, it would be found to be curiously permanent. Occasionally Assamis hold land in two parts of the village, usually termed the "har" and "chali," in the *har* they cultivate rain and dry crops,† and round their wells those which they wish to water, and in highly irrigated villages this land is frequently double cropped, (a reference to Table A, column 11, will show that the double cropped area increases in a marked degree with the percentage of well irrigation,) adding another to the many difficulties of the estimation.

#### Actual figures available

120 Statistics showing the actual area commanded by each unit of irrigation might be obtained by recording the fields irrigated from certain selected wells over a term of years, but the variations are so great in individual wells, that this would be necessary for a large number of cases to obtain an average figure. Perhaps the best approximation is to be found by dividing the number of units in highly irrigated villages into the cultivated area. It is necessary to select villages which irrigate from no other source than wells, and from the villages examined presenting the maximum percentages, it is evident that there is a considerable difference in the proportion which the total area ever irrigated bears to the area actually irrigated in any one year by each unit, as it varies from 7 to 150 per cent of the year's irrigation, even when the percentage of the total area of the village irrigated is large. It is influenced mainly by the nature of the soil with reference to its powers of being double cropped, and the class of cultivator, and although for a general estimate we may assume the proportion of *cultivated* area to be allotted to each unit at double its power of yearly irrigation, yet it is evident that the exact allowance to be made should be carefully worked out from existing examples for every tract taken specially in hand.

#### Difficult of estimation

121 The above remarks will, it is hoped, convey an idea of the difficulty of correctly estimating the gross cultivated area which should be allotted to each well under the mixed agricultural conditions which exist in the Doab.

#### Rate must be struck on yearly irrigation.

122 This apportionment of area is only important so far as it effects the mean rate to be borne by the gross area commanded, and the correct distribution of wells. It must be remembered that the interest charge is yearly, and that therefore the area yearly watered has really to pay the whole interest, and this simplifies the calculation considerably. For the double cropped a most embarrassing item of the gross area need not be considered, the maximum yearly command being independent of it, and the construction rate in consequence is calculated on this area, and I think it will be admitted correctly so.

123 Few except those who have enquired into the history of large heavily worked wells can be aware of the complicated nature of the cultivator's agreements and arrangements regarding them.

#### Rath wells

There are two sets of four wells each in Rath Hamirpur, from which no less than 61 *Kachis* irrigate, every man having his particular number of hours or days of work laid down, which were fixed with reference to the share of cost of construction he or his forefathers paid, and so accurately have they estimated the area they can water, that the crops are uniformly good, although they consist of tobacco and opium, both of which suffer seriously from any delay in watering, and these are heavily worked wells with a maximum unit area—see Appendix VIII.

#### Sitapur well

124 Again in Sitapur, Aligarh, *vide* Appendix VII, there are two 8-lift wells working 28 and 32 head of cattle per well respectively. On these all the cultivators work jointly together, and actually count the number of lifts made, so that each day's work may be alike. Now every Assami on these wells has a different area at varying distances, and

\* In detailing the time required to water distant fields they often state double the period required for those near the well, and give the distance as a reason.

† The same crops are often cultivated in one village both wet and dry. Part wet to make a certainty of some return from the cattle available, and part dry in hope of rain.

with crops requiring different depths, waterings and intervals. How complicated their accounts must be can be imagined, and many other instances could be quoted.

Cost of kucha wells.

125. The relative cost of deep masonry or dry brick wells compared with shallow ones is great, it is not so in the case of those which are kucha. The almost universal rate for excavation down to the mota when wet sand is not met with is Rs 1-4-0, whether the depth be 20 or 60 feet, the earth taken out is used for the ramp, and the explanation of the fixed rate is simple, as even a 60 feet well will not give sufficient earth for a ramp. A special class of workmen are paid 4 annas a day, each to cut the hole in the mota and prepare the bottom of the well for the bucket. This costs from Rs 1 to 3, so that even a 60 feet kucha well can be built for Rs 5 if no difficulties are met with, and it may last 100 years or more with no repairs but a yearly cleaning out.

When wet sand or any stratum which will not stand without support is met with above the mota, a lining has to be added, which costs an indefinite sum, varying from 8 annas to Rs 10, and has usually to be renewed yearly. In these cases the well is short lived, and in Table A. interest is charged on the cost of construction, divided by the average number of years wells last in that particular tract.

Cost of kucha wells dependent on sub soil.

126. It may be seen, therefore, that the cost of kucha wells is influenced directly by the nature of the soil. Masonry wells are practically independent of the nature of the sub-soil so long as a mota exists, they are sunk rather easier through wet sand than clay, and when well built require no other repairs than a yearly cleaning out, their cost therefore depends directly on their depth.

Wood lined wells.

127. Wells lined with wood or other semi-permanent material are considered as kucha, and their cost calculated accordingly.

The people constantly build kucha occasionally dry brick and wood lined, and very seldom masonry wells, directly for irrigation, the reason is obvious, as no crop could bear the direct charge due to a very deep masonry well, but happily the results of their religious feelings here tend to the prosperity of the country.

#### B—The Annual Charges

Annual charges

128. These have been referred to before, and consist in—

- (1) Renewals or that proportion of the first cost of the well which it is necessary to charge yearly to provide for its necessary re-construction.
- (2) The cost of the lift
- (3) Repairs

These require no further explanation. They vary with nearly every class of well, and the average rates for the interest and annual charges combined will be found in Table A. for each district.

#### C—The cost of lifting the quantity of water required

Cost of lifting water

129. This is a simple matter to determine, compared with the interest charge, for an average number of hours work in the day (which has been assumed at 9 for the calculated Tables), a co-efficient can be fixed for any well with its cultivators and cattle.

The mean cost of lifting 100 cubic feet of water from wells in the Doab is 0.454 of an anna,\* and this has been determined by measuring the quantity lifted during the whole day from more than 150 wells distributed over a large area. It varies naturally a good deal with different class of cultivators, bullocks and wells. The full details of experiments will be found in the Tabular Statements, and it is certainly remarkable to note how similar the results are, within certain boundaries which are roughly defined by the various districts, and this shows the great errors that may be made by predicated any general principles from purely local enquiries.

Work done.

130. The work done by any number of bullocks or men at a well is made up of frictional resistance overcome, water, and dead weight lifted, the results of the day's work is

* Cattle Lagor = 0.514	Men Dhenkh = 0.183
Men " = 0.624	" Kan = 0.165
Cattle Kili = 0.830	

given for each well in Table E, friction having been neglected, for it is difficult or impossible to estimate accurately, and the resistance due to it is so much effected by the quantity of lubricating material applied to the pulley, that its admission into the calculations might prove a source of serious error

From the work column in Table F. it will be seen that the percentage of—

Useful work.

131 *Useful work*—decreases directly with the depth to water surface with cattle, increases directly with the capacity of the lift.

Is a maximum with Dhenklies and Râtis, in which there is no loss but friction, and is not much effected by the depth in the case of coolie lifts, as men turn quickly

Total work.

132 *The total work done per head*\*—Is a maximum with cattle working Kih, vide No 492, where 3 064 foot tons per minute were lifted

It is a minimum with hired men working a Dhenkli, vide No 501

Decreases as the number of cattle on each lift are increased, (but cost also decreases.)

Is practically identical for men working Lagor, the actual figures for the five wells experimented are—

No of men.	Depth to water surface	Foot tons per head per minute
6	31	0 487
6	35	0 488
6	30	0 472
8	17	0 440
7	38	0 477

Some of these men were hired, some home labor, the agreement in result is curious, and one ton lifted 6 inches high in one minute may be taken as the maximum work a man can do at such labor

The foot ton the co efficient

133 The foot ton per minute is the co-efficient of the well, and is a more convenient figure than the actual horse-power which, however, can be approximated by dividing it by 15 The mean weights of the various sizes of lift used, Lagor and Kih, are as follow —

Up to 2 cubic feet, 14 lbs	} This is including the ring, which increases the proportional weight of the larger lifts, as it is then usually made of iron The following formula was used in working out the work done —
2 " 3 " " 16 "	
3 " 4 " " 20 "	
4 " 5 " " 24 "	
5 " 6 " " 28 "	
6 " 7 " " 32 "	

$$\text{Height of lift} \times \left\{ \frac{\text{Cubic feet lifted} \times 62.83 + \text{No of lifts} \left( \text{weight of lift} + \frac{\text{weight rope}}{2} \right)}{\text{No of cattle or men} \times \text{No of minutes} \times 2240} \right\}$$

The height of lift taken is the maximum, as it is from that depth the water is drawn over the greater part of a day's work The result of the formula is not strictly accurate, but very nearly so

Depth of watering

134 The depth of water given to the various crops is shown in Table E, it was obtained by dividing the number of cubic feet lifted during the day into the area irrigated during the same period, and as far as its useful effect is concerned should be reduced by the loss from percolation consequent on the length of the water-course

Considering the extended area over which the observations were made, and the variation in climate and soil, the depths agree so far as to show a marvellous knowledge of his business in the Assam, who it could be wished would display a similar care when dealing with canal water

How varied by soil.

135 With regard to soil, it is probable that the rate of evaporation is the principal factor that determines the quantity of water given As the depth of damp is greater in

sand than in *matyar* or *dumat*, so presumably the evaporation is slower. I failed, however, to gather any substantial fact showing that any difference is made in the quantity given to the different soils by the Assam. The amount is so much more varied by the disturbing influences of cost, depth of well, distance of field, quality of cattle, climate, &c, &c, that a rule will with great difficulty be discovered, and cattle or men be of but local application.

The depth and number of waterings given in the Tables are those for a rabi season of deficient rainfall after a good kharif, and 1881-82 was an eminently favorable year for observation.

#### Mean depths

136. The following may be taken as a fair average of the depths given in feet:—

Crop	First watering	After waterings.
Wheat, . . .	2500	1860
Barley, . . .	1860	1860
Tobacco, . . .	1860	1250
Opium, . . .	1860	1250
Carrots, . . .	1860	1250
Potatoes, . . .	1860	1250
„ in ridges,	1250	0930
Gardens, . . .	0930	0930
Sugar, . . .	2500	2500

#### Subsidiary crops

137. Subsidiary crops are usually given the watering required by the major crop.

#### Depth of damp in soil.

138. The depth of damp occasioned by a watering appears to be more affected by the depth of ploughing than by the percolation power of the soil, except in very sandy tracts.

#### Deep ploughing

139. The advantages of deep ploughing as a water retaining measure is here patent, and this perhaps tends to explain why sandy soils have fewer waterings than those of a more clayey nature.

#### Labor rates.

140. The labor rates charged have been already remarked on, they are as follows —

<i>Bullocks,</i>	3 annas per pair,	{ to cover share of purchase „ „ renewals „ „ food while working
<i>Coolie labor hired,</i>	actual rates paid varying from 2 annas to 6 pies	
<i>Labor home,</i>	one anna per day, deducting one man from the total number employed during the day	

*Bullocks*—This rate can scarcely be reduced, it, however, seriously influences the relative cost in districts working bad cattle. The charge for good bullocks should really be raised, but it would have caused much complication in the calculations.

*Home labor*—A man can live on less than one anna a day, but the work is very heavy, particularly coolies working Lagor.

#### Net rates per crop

141. The actual and mean rates are worked out in Tables G and H, and the following rates may be taken as representing the net outlay incurred over the Doab.

Crop	Rs.	As.	Crop	Rs.	As.
Wheat, . . .	8	0	Carrots, . . .	10	0
Wheat and barley, . . .	7	5	Peas, . . .	2	5
Wheat and gram, . . .	7	0	Oats, . . .	10	0
Barley, . . .	6	0	Opium, . . .	15	0
Barley and gram, . . .	5	0	Tobacco, . . .	15	0
Barley and peas, . . .	5	0	Potatoes, . . .	12	5
Safflower, . . .	4	0	Garzen, . . .	12	0
Safflower and carrots, . . .	6	0	Sugar-cane, . . .	12	0
Gram, . . .	2	5			

The above rates only cover cost of food for labor.

Calculations for Dhenki and Rāti imperfect.

142. From the calculated rates it appears that the Rāti is the most economical, and coolie Lagor the dearest method of raising water, but it is necessary to note that in a single

Rāti or Dhenkli two persons are employed, and that owing to the principle of excluding one person on each well from the calculations of cost, only one person per day is charged, and at one anna, as Dhenkli and Rāti are almost universally worked by home labor. If however the cost of lifting by these methods is even doubled, it will still be cheaper than any other system for the same depth, but it is very slow, and when the number of lifts is increased the area of land taken up is considerable, and if culturable its value must be added. The loss from percolation, also due to several small water-courses, would be greater than in the case of a *churru* well.

Rate lower than those calculated by Major Erskine

113 These rates are considerably below that arrived at by Major Erskine, the Secretary to Government, Oudh Revenue Department, in office memo No 2252, dated 16th August, 1881, and the difference is due to the assumption of lower labor rates, the now known reduction in quantity of water used for secondary irrigation, and also the marked variation in quantity which different crops are given

Comparison with canal rates.

144 That these rates represent outlay similar to the actual cash paid for canal water there can be little doubt, and the comparison of rates is instructive, *vide* Appendix XII

145 *The total charge for well irrigation per acre* —The actual total charge for each crop cultivated during the rabi on every well experimented on is shown in Table G, and in the Abstract the mean rates for each district, these rates are at their lowest point, when 150 or more days are required to irrigate the rabi area, and therefore in consulting the record for fair rates such examples should be examined.

There is no difficulty in working out from the tables the maximum rabi area for any well for which the crops to be grown and the quantity of water which can be lifted each day are known

It will be seen from Table B. that, excluding the northern districts, a larger variety and higher class of crops are irrigated in good Kili than in Lagor tracts, and the extent of rabi area will be modified accordingly

Rule for calculating mean rate of watering

146 Taking the percentages of crops given in Table B. and the mean work from Table F, the mean rates for each class and lift can be obtained by multiplying the percentages of crops by the number of days required to water an acre of each, and dividing the total by 100, we thus get the number of days required to water an acre of the average crop, and this figure divided into 150 days will give the rabi command. By adding 50 per cent we have the maximum area which can be yearly irrigated in the kharif and rabi, and the following Table gives the figures for the different districts and classes, and also the cost at cultivator's rates for a suitable well, when the mota can easily be reached. It is evident that highly irrigated crops should pay a larger share of the total rate, but for general purposes it may be equally divided.

TABLE K—Maximum area which can be yearly irrigated and Interest Rate

District.	Class.	Labor	Depth to water surface.	MAXIMUM AREA PER UNIT			No of units per well.	Area per well.	CAPITAL COST			ANNUAL				Remarks.
				Rabi.	Kharif.	Total.			Well.	Fittings.	Total.	Interest at 5 per cent.	Lifts.	Total.	Rate per acre	
Gawnpore, ..	Lagor	Cattle	47	5 0	2 5	7 5	2	15	285	5/-	290	14 5	14/-	28 5	1 9	All crops
Hamirpur, ..	"	"	40	4 2	2 1	6 3	2	12 6	250	6/-	256	12 3	13/-	25 8	2 0	"
Farrukhabad, .	"	"	47 5	6 0	3 0	9 0	1	9 0	220	3/-	223	11 2	8/-	19 2	2 1	"
Mampur, ..	"	"	20	7 5	3 7 5	11 2 5	2	22 5	150	6/-	156	7 8	17/-	24 8	1 1	"
Etab, .	"	"	17 8	5 3	2 6 5	7 9 5	2	15 9	140	6/-	146	7 3	16/-	23 3	1 5	"
Shahjahanpur,	"	"	34 5	7 1	3 5 5	10 6 5	1	10 6 5	170	3/-	173	8 7	9/-	17 7	1 7	"
Lucknow, .	"	"	31	3 3	1 6 5	4 9 5	2	9 9	200	5/-	205	10 3	7/-	17 3	1 7	"
Hardui, .	"	"	30	3 4	1 6	5 0	3	15 0	220	6/-	226	11 3	7/-	18 3	1 2	"
Saharanpur,	"	"	23	3 6	1 8	5 4 0	1	5 4	130	3/-	133	6 7	6/-	12 7	2 3	Garden.
Shahjahanpur,	"	Men	31	3 2	1 6	4 8	3	14 4	150	3/-	153	7 7	5/-	12 7	0 9	All crops.
Lucknow, .	"	"	27 3	3 7	1 8	5 5	3	16 5	140	3/-	143	7 2	5/-	12 2	0 7	"
Hardui, ..	"	"	38	3 2	1 6	4 8	3	14 4	200	3/-	203	10 2	5/-	15 2	1 0	"
Aligarh,	Kali	Cattle	28	7 0	3 5	10 5	3	31 5	240	7/-	247	12 4	20/-	22 4	0 7	"
Muttra,	"	"	61	5 5	2 7 5	8 2 5	2	16 5	360	6/-	366	18 3	15/-	33 3	2 0	"
Etab,	"	"	22	8 3	4 1 5	12 4 5	2	24 9	160	6/-	166	8 3	18/-	26 3	1 0	Only two exam- ples.
Bulandshahr,	"	"	24	6 1	3 1	9 2	3	27 6	220	7/-	227	11 4	20/-	31 4	1 1	All crops
Meerut, .	"	"	26	7 0	3 5	10 5	3	31 5	230	7/-	237	11 9	20/-	31 9	1 0	"
Muzaffarnagar,	"	"	18 8	5 0	2 5	7 5	4	30 0	230	3/-	233	11 7	10/-	21 7	0 7	{ Only one ex- ample Calculated at whea- r 50 per cent. and watering, and gar- den 60 per cent.
Bijnor,	"	"	16	3 7	1 8 5	5 5 5	4	22 2	200	3/-	203	10 2	9/-	19 2	0 9	
Moradabad, .	"	"	19	6 5	3 2 5	9 7 5	2	19 5	140	5/-	145	7 3	9/-	16 3	0 9	All crops.
Bareilly, .	"	"	38	3 7	1 8 5	5 5 5	1	5 5 5	180	3/-	183	9 2	8/-	17 2	3 0	"
Shahjahanpur,	Dhenkli or Rabi.	Men	20	1 0	0 5	1 5	1	1 5	3 0	1/-	4 0	0 2	1/-	1 2	0 8	Garden kucha wells.
Farrukhabad,			16	1 4	0 7	2 1	1	2 1	6 0	1/-	7 0	0 4	1/-	1 4	0 7	"
Bijnor, .			21	0 9	0 4 5	1 3 5	1	1 3 5	3 0	1/-	4 0	0 2	1/-	1 2	0 9	"
Moradabad, .			13 3	1 8	0 9	2 7	1	2 7	2 0	1/-	3 0	0 2	1/-	1 2	0 5	"
Bareilly,			9	2 0	1 0	3 0	1	3 0	2 0	1/-	3 0	0 2	1/-	1 2	0 4	"
Hardui, .			10	4 0	2 0	6 0	1	6 0	4 0	1/-	5 0	0 3	1/-	1 3	0 2	"

The figures in column "maximum area per unit rabi" should be contrasted with the mean results at end of Table B—which show actuals

Table K shows also the incidence of the annual charges per acre, but it is evident that these figures are the very lowest that can possibly be worked to under the most favorable conditions.

Cost of irrigation for standard crops

147 For purposes of comparison the total cost of irrigating one acre each of wheat, opium, and sugar are given below

TABLE L.

District	WHEAT					OPIMUM					SUGAR					Remarks
	Kih	Lagor	Men	Dhenkh	Rati	Kih.	Lagor	Men	Dhenkh	Rati	Kih	Lagor	Men	Dhenkh	Rati	
Cawnpore,		11 9	..		..		14 9						.			The rates vary according to the number of waterings given and the quantity of water lifted per unit.
Hamirpur,	..	10 2					14 7	..			.	16 0			.	
Farukhabad,	...	12 6		4 6		.	16 4	.	5 8				.	.		
Mainpuri, .		8 1					15 8	.		..		12 3	.			
Etah,	7 5	12 8				11 5	19 4				9 0	15 5				
Aligarh, .	7 6					15 7	.	.	.	..						
Muttra,	10 7					.		.	.				.			
Bulandshahr,	9 0		.			.					11 1		..		.	
Meerut, ...	8 0	..						.			14 4				.	
Muzaffarnagar,	8 1	..	.					.			12 2					
Saharanpur,	.		.			15 3	.	.				.		.		
Bijnor, ..							.	.			9 7	.		6 9		
Moradabad,	3 5	.		1 5				.	.		9 3			4 5		
Bareilly, .	6 0				2 1			.			.				..	
Shahjahanpur,		3 7	4 0	2 0	1 9						.	5 7	7 1	4 0	2 8	
Lucknow,		17 1	7 7	.		.	21 8	9 7			.	27 0	10 8			
Hardoi,			8 0	2 3	2 7			11 1	3 5	4 1			26 0	7 7	9 3	

Value of produce

148 Great difficulty has always been found in estimating the gross produce of an acre of any crop, and even when found, it is sometimes impossible to fix the value accurately. The subsidiary crops often give more profit than is generally thought, and indeed it is hard to understand how the Assam in some districts continues to farm unless the gross outturn is much greater than existing statistics lead us to suppose.

Opium.

149 The Opium Department Administration Report of 1880-81 gives the average produce per beegah for 1880-81 at 4 seers  $3\frac{1}{2}$  chittacks, this equals 675 seers per acre, and at the value given, i.e., Rs 5 per seer, equals Rs 33-12-0 per acre, and the minor profits will probably bring this up to Rs 35. Deducting the greatest charge for watering this, leaves Rs 20 to cover rent and cultivation.

Wheat.

150 Mr W Crooke, C S, the Manager of the Court of Ward's Estate, gives the following as the outturn of wheat in 1880-81 from an actual experiment.



Wheat.	Total area sown.	Total yield			Produce per acre			Remarks.
		m	s.	ch.	m.	s.	ch.	
Canal grain, ..	7 64	120	19	0	15	31	0	Well outturn best, but crop Muzaffar-nagar white wheat showed a stronger tendency to revert to the local type with well than with canal water.
„ bhusa, ..	..	178	10	0	23	16	0	
Wells grain, ..	6 25	111	32	8	17	38	0	
„ bhusa, ..	1	164	0	0	26	13	0	

The value of this produce is probably not under Rs 26, which leaves a margin of nearly Rs 20 as in the case of opium

151 The value of the sugar crop varies greatly according to the class of cultivation. In Lucknow and Hardui the crops examined were fine eating cane, which explains the high cost of irrigation, and at the average rate from even moderate crops, there will remain a large margin to cover cultivation and profit, vide Shahjahanpur Settlement Report, sec 11, para 37

## EXTENSION OF WELL IRRIGATION.

A rate of Rs 2 necessary to cover interest on construction.

152. From the calculations which have been made of the cost of irrigation from wells, the result arrived at has been that a rate of Rs 2 must be charged on the maximum area irrigable in the year, to cover the expenditure on construction under the most favorable conditions, and that the cost of the food consumed by the labor employed to fully water any crop will amount to about 30 per cent of its gross value

The calculated area a maximum.

153 The maximum area as calculated is certainly 100 per cent over the average arrived at in practice, this is evident from the areas shown in column 35,\* Table A, and from the figures kindly collected for me by Mr A Harrington, C S, vide Appendix IV, where the average of 3,716 lifts gives 3 acres as the mean area irrigated in the rabi, and 5 acres as the maximum area irrigable in the year. The actual area irrigated in the year being only 3 21 acres, and this in Rai Bareilly, where the mota is plentiful and taccavi advances have been freely taken. It is evident that there is no room for expansion in these figures. Well, unlike canal irrigation, is not elastic. In famine years the possible area from wells is reduced by the weakness of the cattle and men, the increased depth and number of waterings required, and the diminution of the supply, while canals being snow-fed, the supply is increased by drought, and the area by the greater care taken with distribution, we have nothing therefore to hope for from an increase in area, and it is clear that purely hired labor cannot be extensively employed, for not only would the cost of irrigation be enormously increased, but the daily work done would be reduced

Percolation wells costly to irrigate from.

154 Percolation or wells with a bad supply are not only in general more costly to construct, but much more expensive to irrigate from than mota wells. All the calculations of work have been made on the assumption of a good supply being available, the qualifying factor being the power of the men and cattle. If, however, they have to stop constantly to allow the supply to accumulate in the well, the amount of work they can do in the day will be lessened

Well construction by Government cannot, I think, be successful in tracts in which there are either too great or too few facilities for irrigation, and unfortunately the districts first selected for experiment suffer doubly on these accounts

Cawnpore wells.

155 In Ghatampur, Cawnpore District, the depth to water surface is 60 feet, this limits irrigation to the most favorable soils and crops, and increases greatly the charge per acre due to construction, and close to the wells which have been built, costing about Rs 250 each, good kucha wells, costing Rs 15, and giving an equal supply, are not impossible.

Moradabad wells.

156 In Moradabad exactly opposite conditions prevail—water is 10 feet from the surface, and the mota, though not unknown, is very scarce, owing to the climate, however irrigation, though desirable in ordinary years, is only absolutely necessary for a few crops, and a limited number of waterings is given. It has been shown that the cost of irrigation by Dhenkli and Rātis from a depth of 10 feet is much cheaper than by cattle from a depth of 20 or 30 feet, and it appears quite certain that the wells now being built, except when on the mota, will not give a sufficient supply for *churrus* working until the water surface has been reduced to 25 feet to give the necessary head. The yearly command of area in Moradabad may certainly be fairly fixed at a higher figure than in Cawnpore, as a less number of waterings is necessary, but the cost of the wells is also greater, and the charge for an annual Dhenkli well is insignificant. Both classes will suffer in drought, the masonry well probably the most, as it will give no supply at all if the sub-soil surface falls considerably, while Dhenklis and Rātis can be worked up to 25 feet. We must, therefore, look with diffidence for favorable financial results from these experiments

Interesting as a scientific experiment.

157. The Moradabad wells are most interesting in an Engineering sense, for except

\* Column 35 shows the area in acres per lift, and in many instances two or three units or pairs of cattle are used per lift, this is noted in the column of Remarks.

in the few instances when a clay or kunkur layer has been met with, the cylinders rest on pure sand, from which, as before noted, it is impossible to directly draw water without injury to the well. Wood and iron pipes from 5 inches to 8 inches diameter have been sunk to depths varying from 10 to 80 feet below the bottom of the wells, but except in one or two instances without meeting with any moi

Three main experiments have been made—

1<sup>st</sup> —With the pipe head resting in sand, the well having no bottom. Depth of water = 20 feet.

2<sup>nd</sup> —With the pipe head resting in ballast, forming a permeable bottom to the well, which admitted of supply both from the area of the bottom of the well and from the pipe. Depth of water = 16 feet.

3<sup>rd</sup> —With the pipe head embedded in concrete, forming an impermeable bottom to the well, all the supply had to come through a pipe 5 inches internal diameter. Depth of water = 16 feet.

The first experiment was made on a number of wells, and resulted in a rapid exhaustion of the water, the sand rising several feet into the wells causing the cylinders to sink.

The second experiment gave similar results.

The third experiment was carried out on the Chak Dhunowrie a 2-lift well. On the first two days water sufficient for one lift was obtained without injury to the well, but not until the surface had been reduced about 12 feet. On the third and following days, when work was stopped and the water was allowed to rise in the well, a sand discharge took place from the pipe, which had remained clear during the day\*. Full reports on this experiment have not yet been received, and it may be possible to form a pocket of ballast at the bottom of the pipe which would stop the sand draw but a largely increased supply cannot be anticipated.

Appendix IX gives the progress of the wells under direct construction by Government up to the 11th May, 1882.

The experiments might judiciously have been confined to one or two wells until the possibility of construction in such a position had been demonstrated.

158 Great care must, therefore be exercised in the selection of suitable sites, and all natural advantages secured, and this I fear will seriously prejudice the chances of the success of any large project. Well irrigation has been practised for such a long period, that the people have already extended irrigation to very near the natural limits of "available labor," "necessity for water," and "the power of obtaining it cheaply." A careful study of the statistics in Table A. will show that the percentage of the cultivated area irrigated in tracts of equal demand very fairly corresponds with the opportunities of obtaining the supply, and I fear all that we can do with a prospect of financial success is to fill up the gaps that remain, and above all attend to the repairs of existing, though injured, wells, which very often only need the necessary tools, advice and a small advance.

159 Excepting Muttra, where there are strong indications of exhaustion of the sub-soil supply, the best well irrigation occurs curiously enough in canal districts and I think the explanation is to be found in the increased prosperity of the people which enables them to keep better cattle, and the tracts in which the sub-soil water level has been raised by percolation from the canal offer the greatest advantages for well extension. I have not as yet been able to get the agricultural statistics of the villages in the Aligarh District recently debarred from canal irrigation, but I am confident it will be found that they have even now, very nearly as large a percentage of irrigation from wells, both new and old, as they had formerly from the canal, and this without advantages †.

160 There are many advantages gained by selecting such tracts for wells, the water is near the surface, money and cattle plentiful, the best possible drainage system is adopted, and the canal supply can be utilized in places where it is more needed.

\* This result is very curious.

† Since received, vide Appendix II.

Extensive projects not advisable.

The best irrigation in Canal districts.

Tracts with artificial high water surface the best for Government wells.

**The Bulandshahr District.**

161 The Bulandshahr District also offers facilities for extension of well irrigation, particularly in those parts of parganas Ahar, Shikampur, Sahana and Anupshahr, to which the canal does not reach, the mota is scattered, but suitable positions for wells will be found in most villages, there is plenty of good *dumat* soil, the best for the purpose, *and the existing irrigation is high class* Mr S Growse, C S, the Collector, kindly obtained the statistics of the worst villages for me, they are too voluminous to be put up with this Report, but will be forwarded to the Director of Agriculture separately

**Advances.**

162 Direct Government agency being deprecated, the arrangements for advance and recovery of the interest become matters of great importance Zemindars do not care to take advances, even if anxious to improve their estates, for they, like Government, are not certain of financial success unless they are self-cultivating, and advances cannot be made to individual tenants for want of security

**How best made.**

163 But we find few wells worked by a single cultivator, a community is more stable than an individual, and if joint agreements, fixing shares, &c, between the Zemindar on the one hand and the cultivators interested on the other, were arranged by the advancing officer, the Zemindars in most cases would give the required security, particularly if the interest were not payable as such, but as a fixed charge per acre on the land benefited, the advance being regarded as what it truly is, *viz*, sunk in the ground for its permanent benefit

**Khāra wells.**

164 The water of certain wells is bitter, called *Lhāra*, which is caused most probably by solution of salts in the soil, as such wells are only found in certain localities, notably Muttra The water of these wells is said to be good for the rabi, if rain also falls, but not alone, not good for indigo or cotton, but it is always preferred for tobacco

**Kyaries.**

165 With reference to canals, attention may be drawn to the great importance of Kyaries, the compartments into which the field is divided, and on which the whole system of distribution depends The quantity of water used for irrigation per acre by canals is three times as great as by wells, and a strict adherence to Kyaries should result in an enormous extension of area

**Decrease in culturable area**

166 Another point of consideration is the power canal water possesses of bringing culturable land into cultivation, very poor land will often not repay the cost of well water, but the charge is so low, that when canal water is newly introduced into a village it has a strong tendency to lower the percentage of culturable area, if properly distributed, *vide* Appendix VI

**Extract from Diary**

167 A general account of the villages visited is given in Appendix X

**Apology**

168 In conclusion, I trust that the imperfections and length of this Report will be forgotten in the interest which attaches to the subject I may add that the letterpress is chiefly explanatory of the Tabular Statements, (which should be studied as containing a careful abstract of all the information collected,) and is no index of the labor bestowed on their preparation

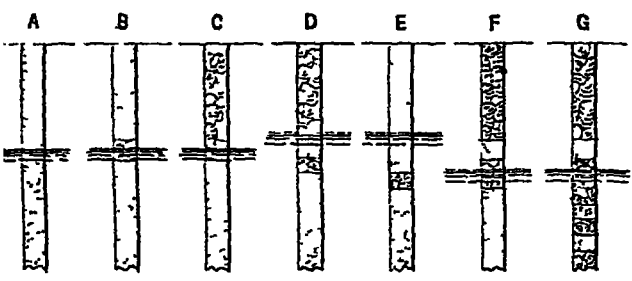
NAINI TAL, }  
14th August, 1882 }

J CLIBBORN, CAPT, B SC,  
Executive Engineer



IRRIGATION FROM WELLS IN NORTH-WEST PROVINCES AND OUDH.

Fig 1



- |    |                                  |                            |
|----|----------------------------------|----------------------------|
| A. | Suits kucha wells with Dhenklus. | F becomes D in years of    |
| B. | Masonry well unsuccessful        | heavy rainfall or when     |
| C. | Dry brick or masonry wells       | canal is opened, and ku-   |
| D. | Kucha wells unlined.             | cha wells suffer, but sup- |
| E. | Masonry or lined kucha wells     | ply would be increased in  |
| F. | " " " "                          | masonry wells              |
| G. | " " " "                          |                            |

Fig 2

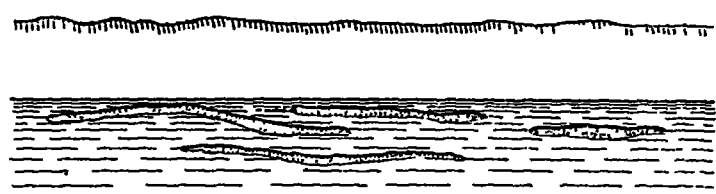


Fig 3

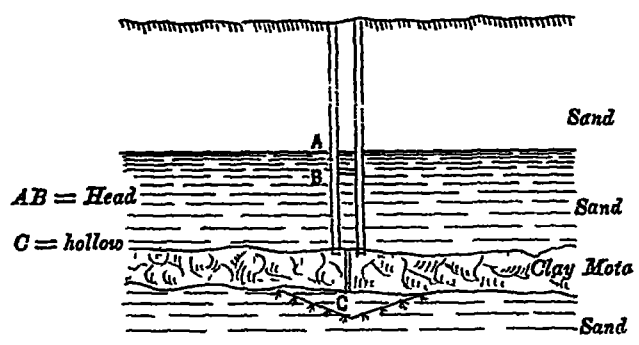


Fig 5

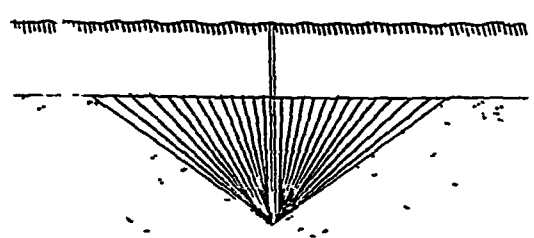
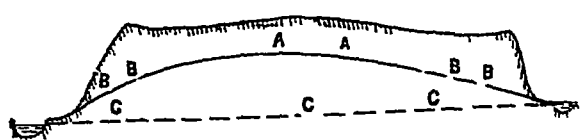


Fig 7



- |        |   |
|--------|---|
| Sand.  | — |
| Clay.  | — |
| Water. | — |

Fig 9

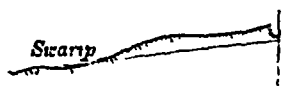


Fig 4

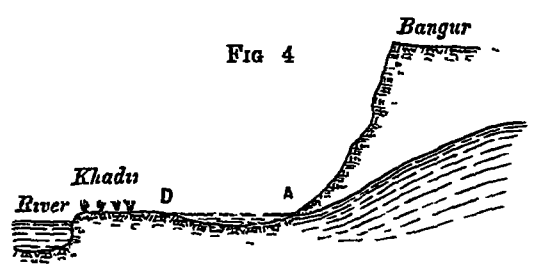


Fig 6

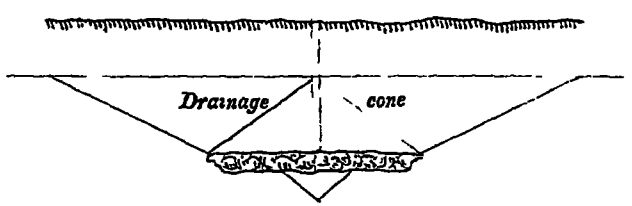


Fig 8

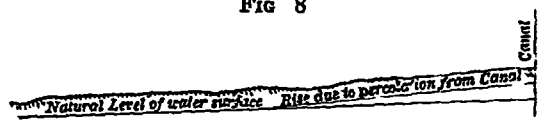
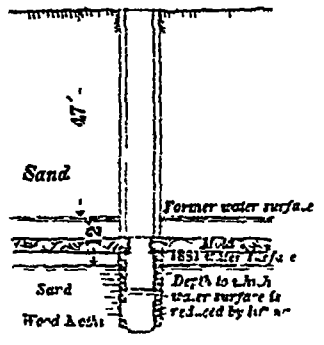


Fig 10





# IRRIGATION FROM WELLS IN NORTH-WEST PROVINCES AND OUDH.

FIGURE 10 11

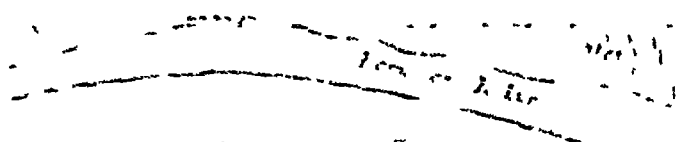


FIG 12

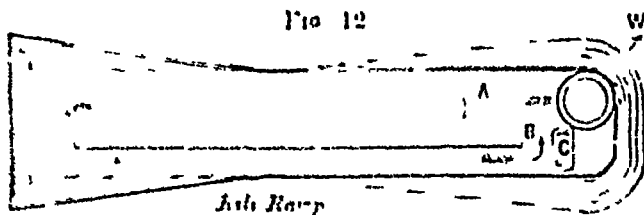


FIG 1



FIG 14

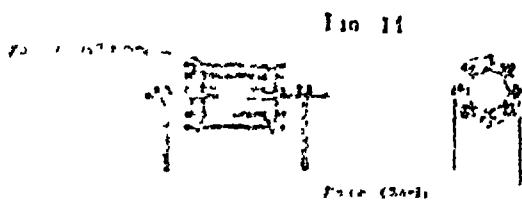


FIG 15

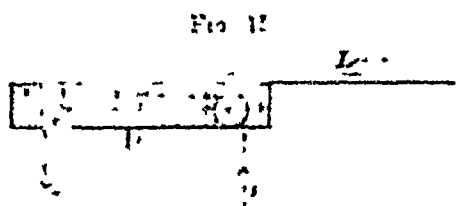


FIG 16

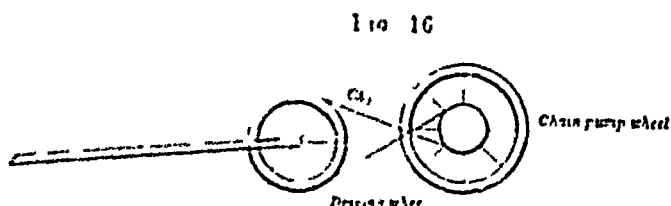


FIG 17

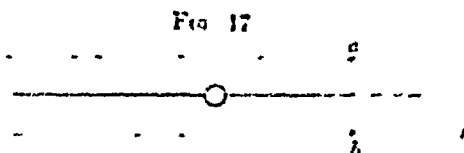


FIG 18

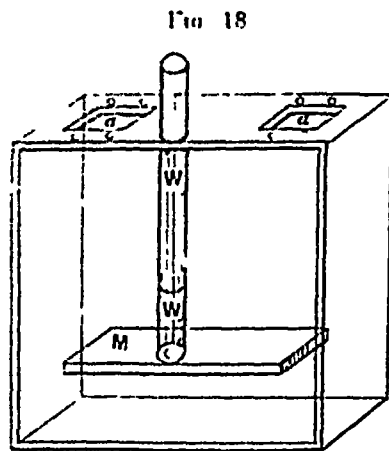


FIG 19

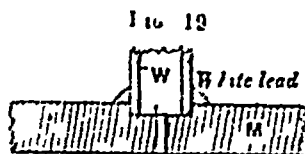
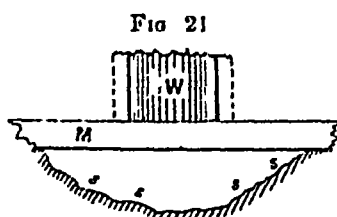
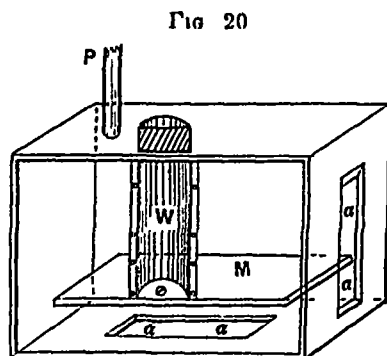


FIG 21



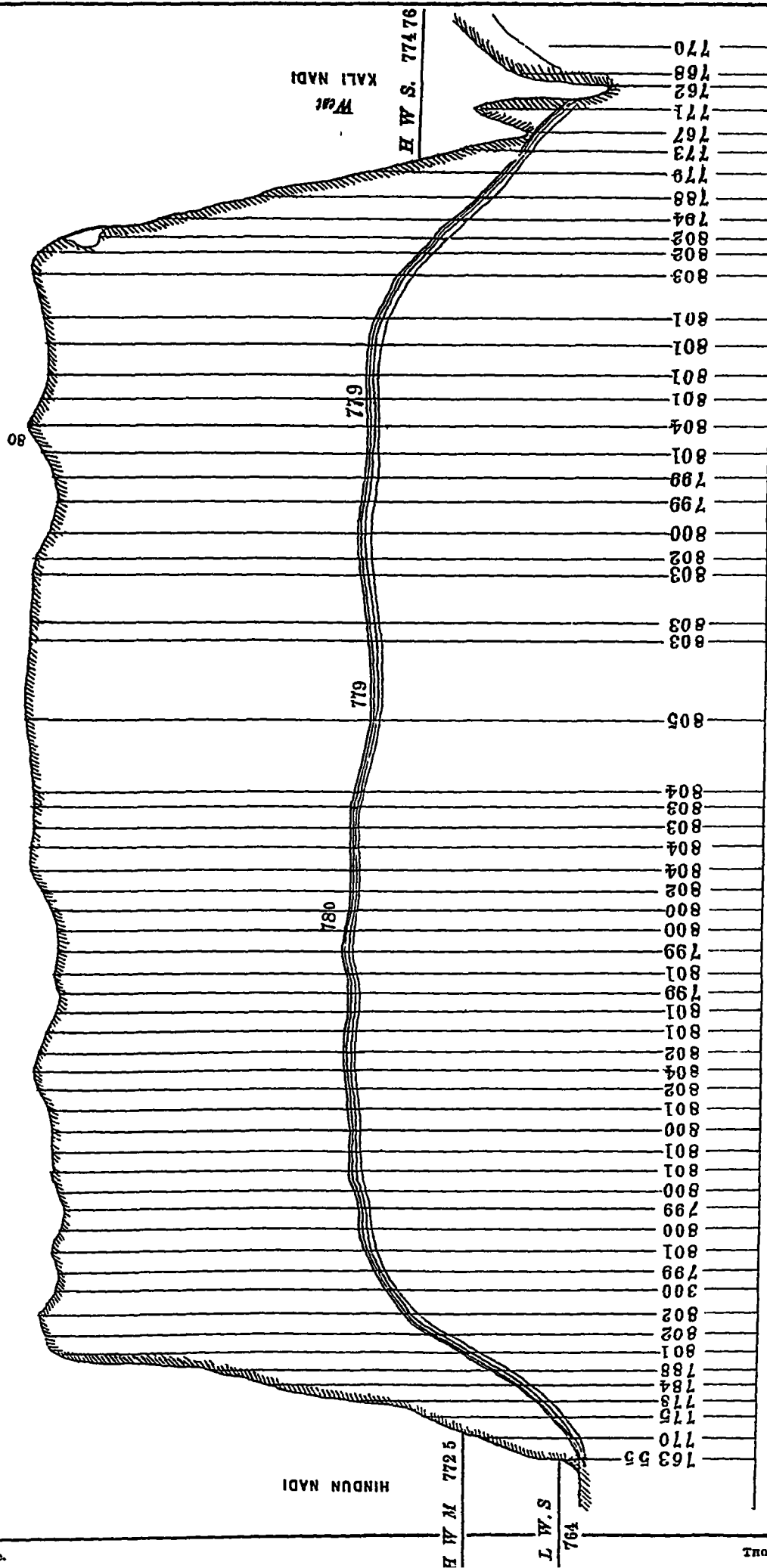
Sand, ---  
Clay, ---  
Water, ---

FIG 20









*Horizontal Scale, 1 Inch to 1 Mile.*  
*Vertical " 10 Feet to 1 Foot.*



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**NOTE**

**ON THE**

**CONSTRUCTION OF WELLS ON THE AWA**  
**ESTATE.**

**BY**

**W. J. WILSON,**

**EXECUTIVE ENGINEER, DEPARTMENT OF AGRICULTURE AND COMMERCE**

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# NOTE ON THE CONSTRUCTION OF WELLS IN THE AWA ESTATE.

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Two parts of the Awa Estate—both in the Etah District—have been selected by Mr Crooke for the purpose of commencing a systematic scheme of well construction. One is part of the Jaithra Circle, situated in the Azamnagar Pargana between the Kālī Nadi and the Burhganga. The other is the Khwājapūr Circle, in the Jalesar Pargana between the Domaria and Sirsa Nadis. The conditions of well construction in the two tracts being very different, I propose to discuss them separately under the following heads —

- 1 Description of the wells now used
  - 2 The area irrigable from a well
  - 3 The cost of irrigation
  - 4 The construction of masonry wells.
  5. The cost of masonry wells
  - 6 Report of work done and in progress
- 

## JAITHRA CIRCLE.

### I DESCRIPTION OF THE WELLS NOW USED

2. Two Plates are attached showing the villages in the Jaithra Circle in which wells are being made. *Plate No I*, which is compiled partly from the Aliganj Tahsil Map and partly from a tracing kindly supplied by Major J. C Ross, R E, shows the position of the villages with respect to the Fatehgarh Branch of the Lower Ganges Canal and the Canal Distributaries

A drainage line passes from the village Pachhenda Pahárpur to the north of Dhúmri, through Jaithra and Khuria Lagar Sahai to Targawan, and thence *via* Jamlapur into the Kālī Nadi. The country between the drainage line and the Kālī Nadi is partially irrigated by a system of distributaries of the Fatehgarh Branch of the Lower Ganges Canal

The tract between the Targawan drainage line and the Fatehgarh Branch is not to be irrigated from the canal at present, but it is probable that the land between the canal and the large dhák jungle will be ultimately irrigated. Throughout this tract the drainage depressions are very marked, but during the rains the drainage lines consist of a series of *jhils* separated by necks of higher land. During heavy rain the water flows along the drainage lines from one depression to another, but after a few days the flow ceases and the *jhils* remain full. The soil is generally *bhúr* or light *dumat*. The surface of the ground is uneven, and the rain water collects in numerous small hollows

Owing to these circumstances a large proportion of the rainfall sinks into the ground, and at the end of the rains the depth to the sub-soil water from the surface of the ground is from 6 to 8 feet, except in sand hills and locally high places. In the hot months water is usually found from 10 to 12 feet below the surface of the ground, and the villagers say that in a year of drought it falls another 5 or 6 feet

Well irrigation is very general throughout the tract, and helps to lower the level of the sub-soil water in the *rabi* season. The introduction of canal irrigation would reduce the area irrigated from wells, and diminish the quantity of sub-soil water removed by them. There is no doubt that the tract has been rightly debarred from canal irrigation

- 3 In *Plate No I* the debarred tract is colored black, except that part of it which is

included in the Awa Estate, which is colored red. The Estate villages are shown on a larger scale in *Plate No II*.

The whole of Bahgon, Tigra Bhamora, and Mahaya, about three-fourths of Jaithra, and half of Khirna Lagar Sahai—or about 7,500 acres—are without canal irrigation.

4. The land of these villages is divided into two tracts, which may be called—

- (i), the spring well tract, and
- (ii), the percolation well tract.

In the former spring wells are easily made by the villagers. It includes a few fields in Jaithra, but is chiefly in Bahgon (*Plate No II*).

In Jaithra there is one masonry well built by a cultivator, which reaches the spring. Another well has been sunk, but the "mota" has not been pierced. During last cold weather one kucha spring well was used for irrigation.

In Bahgon during the last rabi 6 pukka spring wells, working 14 buckets, and 26 kucha spring wells, working 39 buckets, were used for irrigation.

In Khirna Lagar Sahai, Tigra Bhamora, and Mahaya, there are no spring wells.

5. The soil sections in the spring wells in Bahgon vary considerably, but as a rule there are from 4 to 9 feet of a sandy loam, called *lelwa*, above the clay. In some wells there is no lelwa, clay being found at or above the percolation level. In others there are two distinct beds of lelwa separated by a stratum of clay.

It is necessary to support the sandy loam by coils of interwoven twigs of arhar, cotton, or dhák, and the villagers say that they cannot make a kucha well if this stratum is more than 9 or 10 feet thick, as the pressure causes the coils of twigs to bulge inwards.

The thickness of the mota is said to vary from 6 to 18 feet, but in some places it is so thick that the villagers have been unable to get through it to tap the spring.

6. The life of a kucha spring well depends on the nature of the upper soil, the thickness of lelwa and the rainfall. It averages from two to three years.

The cost of the well depends on the thickness of the bed of lelwa, which must be supported by coils of twigs, and on the thickness of clay, which must be dug in order to get a sufficient supply of water. It appears to vary from Rs 3 to 10.

Some of the wells give enough water for one, and others for two buckets.

7. The pukka spring wells are made of block lankar or bricks set in mud. On one of them four buckets, and on six of them two buckets, are worked.

8. In the percolation well tract only two spring wells exist. They are in the Jaithra Indigo Factory, and were built some 60 years ago. One well, 12 feet in diameter, is said to have cost Rs 1,300, the other, 8 feet in diameter, Rs 850.

*Figs. 1 and 2, Plate No IV* are sections of the kucha percolation wells made by the villagers. More than three hundred of these wells were used for irrigation during the last rabi season.

If the soil is sufficiently firm the well is dug in the form of the frustrum of a cone, 4 to 5 feet wide at the top and 9 feet wide at the percolation level (*Fig 1*). If the soil is too sandy to admit of this, the section shown in *Fig 2* is adopted, and the trunk of a *Lhajur* tree is laid across the excavation in order to support the woodwork on which the bucket is worked.

A cylinder made of coils of interwoven twigs is sunk from 5 to 6 feet below the percolation level.

The cost of making such a well is difficult to ascertain, but the following appears a fair estimate —

	RS	A	P		RS	A	P
Earthwork, . . . . .	0	10	0				
Making 20 to 30 coil of twigs, .. ..	0	10	0	to	0	15	0
Sinking cylinder, 6 to 8 men for 2 days, at Re 0-1-0, 0 12 0					1	0	0
Food for madad, . . . . .	1	8	0		2	0	0
Total,	3	8	0	to	4	9	0

The *Lhachhis* and other small cultivators club together to make their wells, and no actual cash expenditure is incurred, but the men who have larger holdings employ hired labor

There is a good deal of difference in the wells. Those sunk in coarse sand give much more water than those in fine sand. The sand that comes into the well is cleared out once or twice a day, and is put on the ledge behind the cylinder. So long as a well remains in good order, the older it is the more water it gives.

The wells are made as soon as the rabi sowings are completed. Last year they were being made as late as the middle of December. Irrigation for the earlier sown rabi crops is frequently required before the wells are ready, and the labor now spent in making the kucha wells would be more profitably employed in irrigating from pukka wells.

The *Lhachhis* take care of their wells and sometimes make them last for two years, but by far the greater number of the percolation wells are used for only one season.

9 There are 18 masonry percolation wells in Jaithra, and on three of them two buckets are worked. Some are made of kankar, but most are of under-burnt, wedge-shaped bricks set in mud. They are 6 to 8 feet in diameter, and have been sunk from 10 to 15 feet below the percolation level. They are made only in places where experience with kucha wells has shown the sand to be coarse and to give a good supply of water. They require to be cleared out occasionally.

Their chief advantage is their durability. In a year of drought they give very little water, the cylinders not being deep enough.

10 The water lift in general use in these villages is the single bucket with inclined bullock run. The cattle are worked on the *nagaur* system, the rope remaining attached to the yoke while the bullocks ascend the run. The buckets are small, those which have been measured containing from 14 to 20 gallons. Buckets that have been in use for some time, and have been torn and repaired, contain much less than new buckets. The cattle are much smaller than those used in the Jalesar pargana.

To work one bucket two men are employed, one to drive the bullocks, and the other to fill and empty the bucket. When two buckets are worked on a well the bullock runs are parallel to each other on the same side of the well, and one man is able to attend to both buckets, while the second drives the two pair of cattle. Hence a considerable saving of manual labor is effected by working two buckets on the same well. When four buckets are worked, two are fixed on one side and two on the other side of the well.

The *dhenkli* and *ráhat*, or *charlhi*, are occasionally used by *Lhachhis* and small cultivators.

## II THE AREA IRRIGABLE FROM A WELL

11 Tables I and II give the area irrigated during last rabi by a number of spring and percolation wells in villages of the Jaithra Circle. The average results obtained are at first sight rather surprising, the area irrigated per bucket from spring wells being 2.32 acres, while from percolation wells it is 2.82 acres. It will be noticed too that the area irrigated from the pukka spring wells was only 1.75 acres per bucket, while from the kucha spring wells it was 2.63 acres.

This is due (i), to some of the masonry wells being in a bad state of repair, (ii), to the



area under rabi round some of the wells being insufficient to keep them constantly at work, and (ii), to the cultivated fields being scattered and at a considerable distance from some of the wells. There is a good deal of *usar* in the spring well tract, and the water is sometimes taken a distance of one or two furlongs through waste land in order to get to a field to be irrigated.

In the percolation well tract there is not much *usar*. The wells are made after the rabi sowings have been completed, and their positions are chosen with respect to the fields to be irrigated. The area round a percolation well is compact, and is more easily irrigated than the scattered fields round a spring well.

12. The villagers say that if a well gives enough water one bucket can irrigate 20 *kucha bigahs*, or about 4 acres, in the rabi season, and this area was attained on some of the single-bucket wells. The wells now being made should irrigate 8 acres per bucket, which is very little more than the average obtained from the wells on which irrigation was recorded.

13. In estimating the area *irrigable* from a masonry well, it is necessary to consider the system of cultivation adopted in the fields round the well.

The *gauhan* lands, which are immediately round a village, often yield two crops a year.

The *barha*, or outlying lands, are sown only once a year, and it is customary to alternate *kharif* and *rabi* crops. An exception must be made, however, in the case of the *tara*, or low-lying lands, as, owing to their being under water during the rains, no *kharif* crop except rice can be sown in them, and it is a common practice to sow *rabi* crops in these fields every year.

*Mayha* lands appear as a rule to be sown only once a year.

14. The land of a village may, therefore, be divided into two classes —

- A. Fields in which *rabi* crops are sown every year, comprising the *gauhan* and *tara*;
- B. Fields in which *rabi* crops are sown every second year, comprising the rest of the village.

In fields of class A, the maximum area that can be irrigated from a well is the area that can be irrigated in the *rabi* season, or 3 acres per bucket. But in fields of class B, the irrigable area is twice the area that can be irrigated in one *rabi* season, or 6 acres per bucket.

It is assumed that the cultivation round a well in the outlying lands is so arranged that half the land is under *rabi* and half under *kharif* crops in each year. If the whole of the land is under *kharif* one year and under *rabi* the next year, half the irrigating power of the well will be lost, as the well will only be worked during every second cold season.

15. The irrigation of *kharif* crops is not taken into account, but it will be seen that this does not affect the result. In the *gauhan* the fields which are irrigated during the hot weather and rains are also irrigated in the *rabi* season. In the outlying lands the fields of *juar* or *bajra* that may be irrigated were under *rabi* during the preceding year, and are included in the irrigable area.

Sugarcane is the only *kharif* crop that requires watering during the cold weather. If any fields round a well are under sugarcane, the area under *rabi* crops that can be irrigated will be reduced, but the total area irrigable from the well will not be altered.

16. The best size of well to build depends on—

- (i), the supply obtainable from the well,
- (i), the relative cost of different sizes, and
- (iii), the position of the well with respect to the land to be irrigated.

Other things being equal, the considerations in para 14 point to the conclusion that larger wells should be built in *gauhan* and *tara* lands than in the outlying lands of a village. In the latter a four-bucket well can irrigate 24 acres, while in the former an eight-bucket well is required to irrigate the same area. In each case the water must go the same distance,

and there will be the same loss in the water-courses. Hence, if a four-bucket well is the best size for the barha lands, an eight-bucket well is the best size for gauhan and tarai lands

### III THE COST OF IRRIGATION

17. It is not necessary to consider the cost of raising the water, as this must be done whatever kind of well is used. But it has been noticed in para 10 that considerable economy in manual labor will result from substituting masonry wells working 2, 4 or 8 buckets for the single-bucket wells now used. 318 single-bucket wells were worked last cold weather in the percolation well tract, and two men were required to each bucket. If these wells were replaced by masonry wells, the labor of 318 men would be liberated, and would be available for irrigating the land which is now dry. Roughly speaking, the labor of one man for 3 months would be saved for each bucket irrigating 3 acres, or of one man for one month per acre irrigated.

18. The cost of making a kucha percolation well is given in para. 8 at Rs 3-8-0 to Rs 4-9-0, but part of this is home labor, and the actual expense to the cultivator is probably about Rs 3 per well, or Re 1 per acre irrigated. If the value of the liberated labor is estimated at Re 1 per acre, the total saving to the villagers by using masonry wells is Rs. 2 per acre. This may be considered a low estimate of the direct gain that will accrue to the cultivator every year from the construction of masonry wells.

Other advantages are—

- (i) The rabi crops can be irrigated as soon as they require water
- (ii) If there is a long break in the rains the kharif crops can be saved
- (iii) In a year of drought the villagers will be nearly as well off for water as in a year of average rainfall

19. If Rs 2 per acre is the cultivator's profit from masonry wells each year his rabi crops are irrigated, this represents his annual profit in the case of gauhan and tarai lands, and his two-yearly profit in outlying lands.

I understand that Mr Crooke has fixed 3 annas per kucha bigah, or very nearly Re 1 per acre as the general rate of enhancement in the Jaithra Circle, and the preceding calculations show that the direct profits to the cultivator, owing to his not having to make kucha wells, and to the saving in manual labor, are at least equal to this. If the cultivators can pay an enhancement of Re 1 per acre in outlying lands, they can afford to pay Rs 2 per acre in gauhan and tarai lands.

20. To sum up for the percolation well tract

One bucket can irrigate 3 acres of rabi crops in a season

Gauhan and tarai lands are usually under rabi crops every year. The irrigable area from a masonry well in these lands is 3 acres per bucket.

Fields in the barha are generally sown with rabi crops every second year. The irrigable area from a well in this land is 6 acres per bucket.

Cultivators can afford to pay twice as much enhancement in gauhan and tarai lands as in the outlying lands of a village. If the rate for the latter is fixed at Re 1 per acre, for the former it should be Rs 2 per acre.

In this case the enhancement on the land round a well will be Rs. 6 per bucket for all classes of land.

21. I have considered only the cultivator's profit by the substitution of masonry wells for kucha wells. But there are places where the soil below the level of the sub-soil water is either lelwa or very fine sand, which yields so little water that percolation wells are not made. In other places the soil above the water surface is so sandy that kucha wells are made with difficulty, and are too costly to prove remunerative. These lands are now unirrigated, and should bear a higher rate of enhancement than fields in which kucha wells are easily made.

If the surface soil is sandy the area irrigable from the well should be reduced from 6 to say 5 acres per bucket in the barha, and from 3 to  $2\frac{1}{2}$  acres in the gauhan

22 As regards the spring well tract Kucha wells cost from Rs 3 to Rs 10 and last from two to three years. Some give enough water for two buckets, others for only one. The annual cost per bucket appears to vary from Re 1 to Rs 3

Some cultivators have asked to have wells built in this tract, and it may be advisable to make them where the strata of lelwa and clay are thickest. But it is rarely expedient to construct masonry wells in lands where kucha spring wells are easily made. As shown in para 35, conditions which favor the construction of kucha spring wells may prevent a really efficient masonry well being built

#### IV THE CONSTRUCTION OF MASONRY WELLS

23 The wells in course of construction at Jaitbra are of three kinds—

- (i) Spring wells in which the masonry steining rests on clay.
- (ii) Spring wells in which the masonry cylinder rests on sand, and the supply is obtained through a tube extending from the bottom of the cylinder to the clay.
- (iii) Percolation wells which are entirely in sand, and the steining of which is made of bricks laid dry, so that water may filter through the joints

The principles which regulate the construction of each kind of well may be briefly noted.

24 *Spring wells in which the masonry steining reaches clay*—These wells obtain their supply from a bed of sand underlying an impermeable stratum below the level of sub-soil water. It is not necessary that the impermeable stratum should be continuous over a large area, and instances are common of good springs being obtained by piercing a clay stratum extending over a few bighas

Fig 3, Plate No IV shows a well sunk into clay and obtaining its supply from the sand below. As the water in the well is removed, the supply is maintained by water coming in through the hole in the clay. At first some sand comes into the well with the water, and it is probable that a basin-shaped reservoir (shown by the dotted line) is formed, of which the clay acts as the roof. The size of the reservoir increases until the velocity of the water filtering into it from the sand becomes so small that the sand is not disturbed

If this explanation of the action in an ordinary spring well is correct, it is evident that so long as the clay stratum is of sufficient extent to allow a reservoir to form beneath it, and is strong enough to support the well above it, a supply of water will be obtained without sand coming into the well

The term "mota" is applied to the stratum of clay, or of clay and kankar, by piercing which a supply of water is obtained. In Majhola a village near Jaitbra, there are some wells which rest on a stratum of nodular kankar without clay, and which give sufficient water for two buckets without sand coming in. But it is rare that such a stratum is found of sufficient thickness and with the nodules close enough together to form an efficient "mota."

25 An ordinary spring well consists of two parts—

- (i), the masonry cylinder, and
- (ii), the hole through the clay

The masonry cylinder is simply a cistern in which the buckets work, and its diameter is regulated by the number and size of the buckets. The first wells made at Jaitbra were 5 feet in diameter and were intended to work two buckets; but it was found that two of the small buckets used there could be worked in a well  $4\frac{1}{2}$  feet in diameter, and that a 6 feet well would take four buckets. To decide the point four buckets were fitted on a well 6 feet in diameter, and a number of cultivators assembled to see the buckets worked, they decided that the well was large enough

The cylinder must be sunk to such a depth that it will contain sufficient water in a year of drought. When a well is worked, the water in it should not fall more than 10 feet, and if the supply is copious the fall will be much less. There should be at least 4 feet of water remaining in the well to allow the buckets to be properly filled. Hence the cylinder should be sunk 14 feet below the level of sub-soil water in a dry year. The cultivators at Jaithra say that they have never known the water to fall more than 5 or 6 feet below the ordinary hot weather level. It should, therefore, be sufficient to sink the wells 20 feet below the average percolation level in the hot season. But as the water may fall lower in a year of drought than the cultivators say, it is proposed to sink the cylinders 25 feet.

26 The spring is generally tapped by simply piercing the clay. But there is sometimes too great a thickness of clay to admit of this, or, after getting through some feet of clay, a stratum of loam, or a thin stratum of sand, may be reached, beneath which lies the true "mota". In these cases it is necessary to sink a small shaft through the upper part of the clay, or through the loam, and to line it with brickwork (*Fig 4, Plate No. IV*).

27 *Spring tube wells*—In places where the clay stratum is too deep to be reached by the masonry stening, a spring well can be made by sinking a pipe from the bottom of the cylinder to the clay (*Fig 5, Plate No. IV*).

In order to keep the sand, on which the curb rests, from coming into the cylinder, it is necessary to ram a plug of concrete about 5 feet thick in the bottom of the well between the pipe and the stening. To allow for this the cylinder should be sunk 30 feet below the ordinary percolation level.

At Moradabad the tubes used in the wells have been made of *gular* wood, which is known to be very durable under water. At Jaithra all the *gular* trees in the Estate villages have been cut down for making curbs, and there are very few trees available for making the tubes. It is proposed, therefore, to use cast-iron tubes with spigot and faucet joints held together by screws. They are much more expensive than wooden tubes, but Mr Meares reports that he finds great difficulty in sinking the latter through sandy soil containing nodular kankar. In some of the trial borings at Jaithra such a stratum has been found overlying the clay, and it is absolutely necessary to get through it, and to bed the tubes firmly into the clay. The cast-iron pipes will go through nodular kankar much more readily than wooden tubes will, and this advantage may more than compensate for their additional cost.

This description of well is analogous to the well with the small shaft shown in *Fig 4*. If the main cylinder of the well is bedded in clay, it is generally easy to bale out the water and to dig the shaft, and the masonry lining is nearly as cheap, and is certainly more durable than the iron or wooden pipe. But if the cylinder rests in sand, it is much easier to sink a pipe through the sand to the clay than to sink a small masonry shaft. The main cylinder of the well might be carried down to the full depth of the small shaft or pipe, but this would be both useless and very expensive.

28 The diameter of the pipe is a most important point to determine.

When a spring well is worked, the water level falls until the water enters the well at the rate at which it is withdrawn by the buckets. The fall represents the head expended in overcoming the resistance to the flow of the water, (1), through the sand from which the supply is drawn, and (2), through the well. The former resistance varies with the degree of coarseness of the sand. The coarser the sand, the more readily will the water flow through it, and the less will be the loss of head. The head lost in the well may be calculated by assuming the water to flow from a reservoir below the clay through the tube into the masonry cistern in which the buckets work. The velocity in the reservoir below the clay, and in the masonry cistern above the tube, is very small and may be neglected.

The hole in the clay in an ordinary well corresponds to the tube in a deep well, and as the diameter of the hole can easily be made as large as desired, and the length is generally small, the loss of head in the well is inconsiderable, and the fall of the water when the well

is worked nearly represents the head expended in overcoming the resistance to the flow of water through the sand below the "mota"

But the following calculations show that in a tube well the loss of head caused by using too small a pipe may be very great—

Let  $v$  = velocity of water through the tube in feet per second

$h$  = head due to the velocity =  $\frac{v^2}{64.4}$

$l$  = length of tube in feet

$d$  = diameter of tube in feet

The head lost in the well is expended in three ways—

- 1 A portion of head, which experiment shows is equal to 0.505  $h$ , is employed in overcoming the resistance at the lower end of the tube
2. A portion, which is equal to  $h$ , is wasted in eddying motion in the masonry reservoir at the upper end of the tube.

The loss of head at the two ends of the tube is therefore equal to 1.505  $h$

- 3 The head expended in overcoming the friction of the tube is equal to  $c \frac{4l}{d} h$ , where  $c$  is a co-efficient which has been found by experiment

The values of these quantities for pipes 50 and 100 feet in length, and of different diameters, and discharging  $\frac{1}{4}$ ,  $\frac{1}{3}$  and  $\frac{1}{2}$  cubic foot per second, are given in Table IV.

The values of  $c$  are those found by Darcy for old and incrustated pipes, and are double the co-efficients for new and clean pipes (Unwin's Hydraulics)

Experiments have shown that the maximum discharge from a 6 feet well worked by bullocks may be taken at 900 cubic feet per hour, or 0.25 cubic foot per second, and from an 8 feet well at 1,800 cubic feet per hour, or 0.5 cubic foot per second. These discharges are rarely obtained by the villagers. If men are employed to work the buckets, 1,200 cubic feet per hour may be raised from a 6 feet well.

It will be seen from the Table that a 3-inch pipe is quite unsuitable for any but the smallest wells. With a discharge of 0.25 cubic foot per second, 4.90 feet of head are lost in 50 feet of 3-inch pipe while only 1.15 foot is lost in a 4-inch pipe of the same length, the difference is nearly 4 feet. With a discharge of 0.5 cubic foot per second, the head lost in 50 feet of 3-inch pipe is 19.58 feet, and in a 5-inch pipe of the same length it is only 1.51 foot, the difference is 18 feet.

The diameter of the pipe should be regulated by its length, and by the size of the well. But it is convenient to have a standard size, and the 5-inch pipe appears most suitable for irrigation wells.

With a discharge of 0.5 cubic foot per second, the head lost in 100 feet of 5-inch pipe is 2.71 feet, and in the same length of 6-inch pipe it is 1.09 feet. The difference is 1.62 feet. If iron pipes are used, the difference in cost between pipes 6 inches and 5 inches in diameter is probably greater than the cost of sinking the main cylinder of the well an extra 2 feet, which will more than allow for the additional loss of head (1.62 feet) caused by using the smaller pipe.

29 *Percolation wells*—Fig 6, Plate No V, is a section of the percolation wells which it is proposed to build. In the lower 5 feet of the steining the bricks are set in mortar, above this the bricks are laid dry to a height of  $4\frac{1}{2}$  feet. This is succeeded by 1 foot in which the bricks are laid in mortar, this again by  $4\frac{1}{2}$  feet, consisting of bricks laid dry, and so on till the cylinder has reached a height of 26 feet, above which to the top the bricks will be set in mortar. The cylinder will be sunk 30 feet and a plug of concrete 5 feet in thickness will be put into it.

30 A paper read by Mr Sutcliffe before the Society of Engineers in December 1877, describes the systems that have been tried in

from tube wells sunk in sand. These wells, commonly known as the "Abyssinian tube wells," consist of wrought-iron tubes connected by screwed sockets, the lowest tubes being furnished with steel points and perforated with holes varying from  $\frac{1}{8}$  to  $\frac{1}{4}$  inch in diameter, extending from 15 inches to 3 feet upwards from the points. The tubes are driven into the ground until a stratum is reached that will yield water. A pump is then attached to the top of the tubes, and on working the pump water is drawn in through the percolations in the lowest tube and is discharged above the surface of the ground. When the lowest tube is in a stratum consisting entirely of fine sand it soon becomes choked, and the sand flows in through the perforations as fast as it is cleared out. The following extract from Mr Sutchiff's paper, which describes some of the plans that have been adopted to overcome this difficulty, is interesting —

"A tube well was driven at Chislehurst into an extremely fine sand, and it was found impossible with the horse-hair strainer to get any supply of clear water. The tubes were withdrawn, and the point screwed off, and the pipe driven in the same hole. The pump was then screwed to the top of the tubes, and four or five barrow-loads of sand pumped up. Previously to doing this, however, six barrow-loads of good clean sharp grit gravel were brought to the spot. The pump was removed, and down the tube, which was only  $1\frac{1}{4}$ -inch internal diameter, as much gravel was forced ramrod fashion as filled up the cavity made by the removal of the sand. The open tube was then withdrawn and a pointed and perforated tube driven into the gravel bed thus formed. A coarse sand tube was dropped into the well to keep back the grit, and upon again attaching the pump the water came freely, and rapidly cleared. *Fig 7, Plate No V* shows the bed of gravel inserted in the manner described. In consequence of the success of this well another was sunk on the same estate with equally satisfactory results, and these two wells have now been in use over two years, and within the last few weeks a third has been added. At Orpington, in Kent, what is known as a blowing sand was dealt with somewhat similarly. Owing to the nature of the sand a cavity could not be made in it as in the previous case. A hole 6 or 7 inches in diameter was therefore bored and piped down with large tubes, until several feet of the quicksand had been passed through. The quicksand was removed from the pipes with an ordinary boring shell, and gravel was rammed down, the large tubes being gradually withdrawn as the work progressed. The small  $1\frac{1}{4}$ -inch tube was then driven into this vertical gravel bed as shown in *Fig 8, Plate No V*, and a good well made, which gave a supply of about 200 gallons per hour. Clay was rammed tightly over the gravel to prevent drainage contaminating the well. The large tube was entirely dispensed with before completing the work.

"Another method of introducing a gravel bed was employed in a dug well at Lewisham in Kent. The dug well became dry last summer, and to obtain a fresh supply a tube well was driven below the bottom of it, and water in a fine silver sand obtained. Gravel was thrown into the dug well, and by its weight gravitated to the spot from which the sand was being drawn. The operation of pumping out the sand and replacing it with gravel was continued until the water became entirely free from sand, and was so plentiful that two pumps were attached to it and the next house supplied from it."

From the description of the system adopted at Orpington, it appears that when the tube was surrounded by a layer of gravel, a discharge of 200 gallons (= 32 cubic feet) per hour was obtained without any sand coming into the well.

31 Mr Bull, C E, has built some wells in which all the bricks from the curb to within a few feet of the ground level are laid dry, and it is said that little or no difficulty is experienced from the sand coming in through the joints. The character of the sand in different wells varies very much, but there can be no doubt that if the steining of a percolation well can be completely surrounded by a layer of small material, such as broken brick (*Fig 6, Plate No V*) the efficiency of the well will be greatly increased.

In 1880 two percolation wells were sunk, but they reached clay within 19 feet of the level of sub-soil water. The area of the surface through which the water can filter is, therefore, much less than in the wells now under construction. The wells gave sufficient water for one bucket without much sand coming in, but when two buckets were worked the

wells rapidly silted up. The earth round one of the wells was cleared out and a trench about 3 feet wide was dug round the cylinder to a depth of 1 foot 6 inches below the percolation level. Some siftings and broken brick were thrown into the trench. A pump raising almost as much water as two small buckets was worked for a fortnight, when it broke down and was replaced by a smaller pump, which was worked for two months. The result was that very little sand came into the well while the material in the trench sank a few inches. Had this plan been adopted immediately after the well was built, it is probable that the broken brick would have sunk more rapidly. It will be tried on one or two of the new wells, and if the results are not satisfactory, a somewhat similar plan to that described by Mr. Sutcliffe as having proved successful at Orpington will be adopted.

A pipe 6 inches in diameter will be sunk about 6 inches from the steining to a depth of 25 feet. Small brick ballast will be rammed into the pipe and forced into the sand at the bottom. The pipe will be withdrawn and as it rises more broken brick will be rammed into it. It will be necessary to sink the pipe in 12 or 15 places at intervals of about 2 feet round the steining. In this way the cylinder should be completely surrounded by broken brick to a distance of from 12 to 18 inches, more of the ballast will be filled into a trench round the well.

32 The filter beds generally used in waterworks for the supply of towns consist of a layer of gravel covered with a layer of sand, and they are generally designed with an area of one square yard for each 700 gallons (= 112 cubic feet) of water to be filtered in 24 hours. This is at the rate of nearly 5 cubic feet per square yard per hour.

The steining of a percolation well with the broken brick and sand round it forms a filter bed. When the well is worked the water will fall a few feet, say 1 foot, and if the well has been sunk 30 feet below the percolation level, and the concrete plug is 5 feet thick, the length of the cylinder through which the water can filter will be 21 feet. If there is a foot of brick ballast all round the steining the area of the outside of the cylinder of broken brick will be

$$21 \times 3\frac{1}{2} \times 10 = 660 \text{ square feet,} \\ = 73 \text{ square yards nearly}$$

If the water passes into the broken brick from the sand at the rate generally allowed in filter beds, the quantity obtainable from the well will be

$$73 \times 5 = 365 \text{ cubic feet per hour,}$$

or fully enough to supply two of the buckets used at Jaitbra.

The velocity of flow through a filter bed is kept very low in order to remove all the mechanical impurities and to oxidize the organic impurities present in the water, and it is probable that a much higher velocity may be permitted without drawing sand into the well. If a rate of 10 cubic feet per square yard per hour can be attained, the well will give sufficient water for four buckets.

33 It remains to consider the effect of a year of drought on these wells. By sinking the cylinder of a spring well 30 feet, allowance is made for a fall of the water surface to the extent of 11 feet in a dry year. If such a fall occur, the length of cylinder of a percolation well through which the water can filter will be reduced from 21 feet to 10 feet, and a discharge at the rate of 20 cubic feet per square yard per hour will be required to supply four buckets. If this rate cannot be attained without bringing sand into the well, either the cylinder must be sunk deeper or the discharge from the well must be reduced.

34 The figures given above show the advantage obtained by making the side of the cylinder permeable to water. If the bricks of the steining are laid in mortar the well must obtain its supply entirely from the sand at the bottom. By throwing broken brick into the bottom of a 6 feet well, a filter bed, having an area of 3 square yards, will be formed, and at the rate of 5 cubic feet per square yard, the discharge will be 15 cubic feet per hour. Even if the rate of discharge can be increased to 20 cubic feet per square yard per second without bringing in sand, the well will not be of much use for irrigation purposes.





80 feet below the water level without reaching clay. Unless a very cheap description of pipe is used it will rarely pay to build spring wells in places where the 'mota' is more than 50 feet deep, and it is in these places that the greatest necessity exists for good percolation wells

## V. THE COST OF MASONRY WELLS

38 *Spring wells with cylinders resting on clay*—Cylinders 6 feet in diameter are made 1 foot thick. The bricks are made segmental to fit the curve of the well, their mean dimensions being 12" × 6" × 3". Two moulds are used—one for headers, the other for stretchers.

One foot in length of the cylinder contains 22 cubic feet of masonry and at Rs 20 per 100 cubic feet, costs Rs 4-6-6

The cost of sinking varies very much. Through lelwa, the progress is much slower than through sand. Getting the cylinder into the clay is expensive, and more wells must be sunk before the average rate can be ascertained, but it should not exceed Rs. 3 per foot

The curbs of wells that are sunk into clay are fitted with iron shoes to facilitate the sinking.

The depth to the percolation level from the surface of the ground averages about 12 feet.

39 The estimated cost of a well the cylinder of which is 6 feet in diameter, sunk 25 feet below the percolation level, and built to a height of 2 feet above it, is as follows.—

	RS.	A.
Curb, fitted with iron shoe, .. .. .	30	0
Masonry cylinder, 39 feet, at Rs 4-6-6 per foot, ..	171	14
Sinking, 25 feet, at Rs 3 per foot, .. .. .	75	0
Earthwork, .. .. .	10	0
	<u>286</u>	<u>14</u>
Establishment, at Rs. 10 per cent., .. .. .	28	11
Tools and plant, at Rs 5 per cent, .. .. .	14	6
Contingencies, .. .. .	20	1
Total Rs, ..	<u>350</u>	<u>0</u>

If a small shaft, 10 feet in length, is required in the clay, the cost of this must be added. The masonry lining may be 3 feet in diameter and 6 inches thick. One foot in length contains 4.5 cubic feet, and costs Re 0-14-6. The cost will be—

	RS.	A.
Curb, .. .. .	5	0
Masonry lining of shaft, 10 feet, .. .. .	9	1
Sinking shaft, .. .. .	10	0
	<u>24</u>	<u>1</u>
Add for establishment, tools and plant and contingencies, ..	5	15
Cost of shaft, ..	<u>30</u>	<u>0</u>

Hence the total cost of the well will be Rs. 380

If these small shafts are required in half the wells, the average cost of the spring wells 6 feet in diameter, will be Rs 365.

In a previous note on the Jauthra wells the average cost of a 5 feet well was estimated

at Rs. 250 A 5 feet well will take only 2 buckets, while a 6 feet well will take 4 buckets. A four-bucket well at Rs. 365 is cheaper than a two-bucket well at Rs. 250

40. These wells may be made more cheaply if the cylinder is not sunk so deep, or if its thickness is decreased

The reasons for sinking the cylinders 25 feet have already been given (paras 25 and 35)

The thickness of the steining may probably be reduced to 10 inches without endangering the stability of the well This will effect a saving of about Rs 25.

The cylinder is strained most severely while it is being sunk, and if it is strong enough to stand sinking, and is properly bedded in the clay, it is not likely to fail when it is used for irrigation Some cylinders 8 feet in diameter and 12 inches thick will shortly be sunk, and if they go down safely, the steining of the 6 feet wells will be reduced to 10 inches

41 No 8 feet wells have yet been made at Jaithra, but two sizes of bricks have been burnt for them.

(1). 10 inches long, suitable for cylinders 15 inches thick

(11). 12 inches long, suitable for cylinders 12 inches thick

One foot in length of an 8 feet cylinder, 15 inches thick, contains 36.3 cubic feet of masonry, and at Rs 20 per 100 cubic feet, costs Rs 7-4-2

The sinking should not cost more than Rs 4 per foot

The estimated cost of an 8 feet well, sunk 25 feet below the percolation level, and built to a height of 14 feet above it, is as follows —

	RS.	A
Curb, fitted with iron shoe, .. .. .	45	0
Masonry cylinder, 39 feet, at Rs 7-4-2 per foot, ..	283	3
Sinking 25 feet, at Rs. 4 per foot, .. .. .	100	0
Earthwork, .. .. .	15	0
	<hr/>	<hr/>
	443	3
Establishment, at Rs 10 per cent, .. .. .	44	5
Tools and Plant, at Rs 5 per cent., .. .. .	22	3
Contingencies, .. .. .	30	5
	<hr/>	<hr/>
	540	0

If a shaft 10 feet deep is sunk in the clay, the additional cost will be almost the same as for a 6 feet well, or Rs 80, and the total cost of the well will be Rs. 570

The average cost of the 8 feet wells will be about Rs. 555.

If the cylinder is made 12 inches thick, a saving of Rs. 50 will be effected.

42 To compare the cost of a 6 feet well with that of an 8 feet well.

A 6 feet well costs from Rs 340 to Rs 365 according as the cylinder is made 10 inches or 12 inches thick.

An 8 feet well costs from Rs 505 to 555 according as the cylinder is made 12 inches or 15 inches thick.

Hence an 8 feet well costs almost exactly half as much again as a 6 feet well, while it will take twice the number of buckets

43 *Spring tube wells* — One of these wells differs from an ordinary spring well in the following details —

(1). The cylinder is 5 feet longer

(11) It is sunk 5 feet deeper

(iii). There is a plug of concrete, 5 feet thick, in the bottom of the well.

(iv) A pipe extends from about 2 feet above the concrete to the clay.

The rate for sinking should be less than in the other wells, as sand only or sand with a little nodular kankar is passed through. There is no necessity to have the curb shod with iron

44. The estimated cost of the cylinder of a 6 feet tube well is as follows—

	RS	A
Curb, .. .. .	18	0
Masonry cylinder, 12 inches thick, 44 feet, at Rs. 4-6-6, ..	193	14
Sinking, 30 feet, at Rs 2 per foot, ..	60	0
Earthwork, .. .. .	10	0
Concrete, 142 cubic feet, at Rs 14 per 100 cubic feet, ..	19	14
	<u>301</u>	<u>12</u>
Establishment, at 10 per cent, .. .. .	30	8
Tools and Plant, at 5 per cent, .. .. .	15	2
Contingencies, .. .. .	22	15
Total, ..	<u>370</u>	<u>0</u>

If the cylinder is made 10 inches thick, a saving of Rs 30 will be effected

45. The estimated cost of the cylinder of an 8 feet tube well is given below—

	RS	A.
Curb, .. .. .	30	0
Masonry cylinder, 15 inches thick, 44 feet, at Rs. 7-4-2, ..	319	7
Sinking, 30 feet, at Rs 3, .. .. .	90	0
Earthwork, .. .. .	15	0
Concrete, 250 cubic feet, at Rs 14 per 100 cubic feet, ..	35	0
	<u>489</u>	<u>7</u>
Establishment, at 10 per cent., .. .. .	48	15
Tools and Plant, at 5 per cent, .. .. .	24	8
Contingencies, .. .. .	27	2
Total, ..	<u>590</u>	<u>0</u>

By making the cylinder 12 inches thick a saving of Rs 60 may be effected

46 To this must be added the cost of the tube, which will vary with the kind of tubes used and the length required It was originally intended to use "gular" wood pipes, which were obtained at Moradabad for 10 annas per foot

For reasons given in para 27, it is necessary to use iron pipes at Jaithra The cheapest pipes in the market are cast-iron pipes with spigot and faucet joints turned and bored The prices of these pipes in Bombay, and the cost of carriage to Agra are given below—

	RS	A	P		RS	A.	P
4-inch pipes cost in Bombay	0	12	0	per foot, and carriage to Agra is	0	9	0
5-inch .. .. .	1	0	0	" .. .. .	0	12	0
6-inch .. .. .	1	4	0	" .. .. .	0	15	0

To this must be added the cost of making holes, screws, &c., which will add about 8 annas per foot to the price The cost of carriage to Jaithra is about 2 annas per foot

Hence total cost of pipes at Jaithra will be—

	RS	A	P	
4-inch pipes, .. .. .	1	15	0	per foot
5-inch .. .. .	2	6	0	"
6-inch .. .. .	2	18	0	"

The objections to this kind of pipe are that the joints project more than an inch beyond the body of the pipe, and the turned and bored surfaces are not long enough to make the joints quite rigid.

It is probable that these pipes can be sunk to a depth of 50 or 60 feet below the bottom of the well without much difficulty. For greater depths it may be necessary to use cast-iron pipes connected by wrought-iron covering hoops

As stated in para 28, the 5-inch pipe is the best size for general use.

The pipe projects at least 2 feet above the concrete, and should be sunk 3 feet into the clay. Hence the length of pipe required is equal to depth of clay below bottom of well + 10 feet.

The cost of the pipe, including sinking when clay is at different depths below the bottom of well, is given below. The cost of sinking is estimated at Re. 0-8-0 per foot

						RS	A	P
Clay	10 feet below bottom of well,	cost of pipe, ..				54	0	0
"	20	"	"	"	"	82	12	0
"	30	"	"	"	"	111	8	0
"	40	"	"	"	"	140	4	0
"	50	"	"	"	"	169	0	0
"	70	"	"	"	"	226	8	0
"	100	"	"	"	"	312	12	0

47 The following Table shows the total cost of a spring tube well when the "mota" is at different depths below the percolation level —

Depth from level of sub-soil water to the mota	ESTIMATED COST OF WELL			
	6 feet in diameter		8 feet in diameter.	
	RS	RS.	RS.	RS
40	394	to 424	584	to 644
50	423	to 453	613	to 673
60	452	to 482	642	to 702
70	480	to 510	670	to 730
80	509	to 539	699	to 759
100	567	to 597	757	to 817
130	653	to 683	843	to 903

48 *Percolation wells.*—The cylinders of these wells are made 6 feet in diameter. They will cost almost exactly the same as the cylinders of spring tube wells of the same diameter. Extra precautions must be taken in sinking them, and this will counterbalance the saving effected by not using mortar in 18 feet of their length. Hence the cost of the cylinder (12 inches thick) will be Rs. 370

If the cylinder is surrounded by broken bricks to a thickness of 12 inches, 1,000 cubic feet of brick ballast will be required. At Jathra this will cost very little, as there is a quantity of lime siftings and broken brick at the kiln, which is useless for any other purpose. But if a number of these wells were made, it would be necessary to burn or purchase the ballast, which would cost about Rs 4 per 100 cubic feet. Hence cost of 1,000 cubic feet of ballast would be Rs 40. To this must be added the cost of sinking it round the cylinder.

If the ballast sinks sufficiently by simply working the well, the expenditure will be very small. Arrangements must be made to keep the trench open and to carry the water raised from the well over the trench. The water will be raised from the well by the cultivators and will be used for irrigation. As the ballast sinks, more will be thrown into the trench. Rs 10 should be sufficient to cover this. In this case the total expenditure on ballast and sinking will be Rs. 50

If it is necessary to sink a pipe round the well and to ram the ballast into it while it is being withdrawn, the cost will be about Rs. 50 greater. The pump must be sunk and lowered in from 12 to 15 places round the cylinder, say 15. The cost of sinking and withdrawing the pipe once, and ramming the ballast into it, will be about Rs. 4, and for doing this 15 times the cost will be Rs. 60. Hence the total expenditure, including ballast, sinking pipe, &c, will be Rs. 100. Therefore the total cost of a percolation well is Rs. 420 to 470.

As mentioned above, the cost of the percolation wells at Jaithra will be less than this, as there is a considerable quantity of waste material at the kiln, which will be used for ballast. The percolation wells first made were 5 feet in diameter, and it was intended to make them all of this size, as it was not expected that they would give water for more than two buckets. But it appears probable that if the cylinder can be entirely surrounded by ballast, the percolation through it will be sufficient for four buckets. Some percolation wells, 6 feet in diameter, have recently been started.

49 The conditions which determine the best size of well to build are given in para 16

It has been estimated (para 42) that an ordinary spring well, 8 feet in diameter, costs half as much again as a well 6 feet in diameter. The former will take twice as many buckets as the latter, hence the relative cost per bucket of the two wells is as 3 to 4. We have to consider whether the advantage in cost which the larger well possesses is neutralized by the additional loss in the channels in irrigating a larger area.

Water is lost in a watercourse in three ways—(i), by soakage into the soil, (ii), by evaporation from the water surface, and (iii), owing to irregularities in the bed, some water is retained in the channel after irrigation has ceased. If the channel has a good slope and is properly made (ii) and (iii) are comparatively small, and the chief loss is by percolation, which varies with the kind of soil through which the watercourse runs.

It is probable that in a given channel the loss by soakage varies nearly as the wetted surface (= wetted perimeter  $\times$  length) of the channel. If the rate of discharge is doubled the wetted perimeter is increased in a much smaller proportion, and the channel may be made longer without increasing the percentage lost by percolation. Hence if all the water raised from a well is sent down one channel and into one field at a time, the proportion lost in the watercourses on an 8 feet well is probably no greater, and may even be less, than that lost on a 6 feet well.

Cultivators are well aware of the economy that results from irrigating on this system, and when the land round a well belongs to different men they frequently combine together to do so. But this cannot always be counted on, and if the irrigation of three or four fields is carried on together the loss in the channels will be increased, and the area irrigated from the 8 feet well will be less than double the area irrigable from a 6 feet well. So long as the area irrigated for bucket on the former exceeds three-fourths of that on the latter, the advantage as regards economy is still on the side of the 8 feet well.

A two-bucket well costs about Rs. 250, and the cost per bucket is about 30 per cent. greater than that of a four-bucket well.

Until a well is made the water supply obtainable from it is uncertain. It varies with the nature of the sand below the "mota," coarse sand yielding water more readily than fine sand. It also depends on the extent of the sandy stratum both horizontally and vertically.

This uncertainty about the supply is the chief objection to making large wells, as after they are made it may be found that the full number of buckets cannot be worked on them. The supply in a spring well is nearly always enough for four, but is frequently insufficient for eight small buckets. The former therefore appears the best size for general use.

Some 8 feet wells are being built in gauhan land near other wells, in which the supply has proved to be ample.

50 As regards spring tube wells. Mr Crooke is of opinion that if he can secure a rate of profit at 6 per cent it will pay him to make wells. Allowing, as in the last para, a profit of Rs 24 from a 6 feet well in outlying lands, and of Rs. 48 from an 8 feet well in the gauhan and tarai, the cost of a 6 feet well must not exceed Rs 400, and of an 8 feet well Rs 800. The Table in para 47 shows that, accepting these limits, a 6 feet well should not be made where the "mota" is more than 40 feet, nor an 8 feet well where the "mota" is more than 100 feet below the level of sub-soil water

51 Next as to percolation wells. Spring tube wells 6 feet in diameter cost Rs 394 to Rs 424 where the "mota" is 40 feet deep, and Rs 423 to Rs 453 where the "mota" is 50 feet deep. If a percolation well giving enough water for four buckets in a year of drought can be made for Rs 400, it should be made wherever the "mota" is more than 40 feet deep in preference to a spring tube well 6 feet in diameter.

52 Wells of any description can be built more cheaply in a year of drought than after a year of average rainfall. If the level of sub-soil water falls 10 feet, the saving in wells of different kinds and sizes will vary from Rs 30 to 50.

## VI. REPORT OF WORK DONE AND IN PROGRESS

53 Two experimental wells were sunk at Jaithra in 1880, in sites chosen by Mr Benson. One of them reached clay at a depth of 18 feet 6 inches. The other was sunk 15 feet 6 inches, and the divers said it was on clay, but this was afterwards found to be incorrect, and the well has been sunk 2 feet 6 inches deeper, and is now on the "mota."

54 In April 1881, a trial boring was made in a spot about three-quarters of a mile from these wells, and clay was found at a depth of 24 feet. The boring apparatus used was of the ordinary kind, consisting of iron rods screwed together, with various tools to be attached to the lowest rod. The soil being sandy, a 3-inch wrought-iron pipe was sunk to keep the bore open, and the tools worked inside the tube. The apparatus proved quite unsuitable for the sandy soil at Jaithra. Each time the tools were withdrawn from the pipe a considerable time was wasted in unscrewing the rods, and only about 1 foot in length of the auger contained sand.

The sand came into the pipe almost as quickly as it was removed. The trial boring occupied three weeks, and cost Rs 26 in labor alone.

55 The two experimental wells made in 1880 are percolation wells, the greater part of the stening below the water surface being made of bricks laid dry. This description of well cannot be sunk into or through clay without great difficulty. Clay having been found within 24 feet of the percolation level in the three places where trials had been made, the wells, which were then started, were made of bricks laid in mortar. Before the end of October, 18 wells had been built and four of them had been sunk 30 feet without reaching clay. Since then the remaining 14 wells have been sunk, but only six of them have reached clay.

56 The variation in the depth to the clay in different parts of the village rendered it necessary to make a more extensive series of trial borings before building any more wells. Some new tools and pipes were ordered in November 1881. They were received in March but some alterations were required, and these were not completed till May.

In the meantime 20 more wells were started, the cylinders being built to a height of only 5 feet pending the results of the trial borings. A reference to Figs 3 to 6, Plate No. IV. and V, will show that up to this height the stening of a spring and percolation well is built in exactly the same way, but above 5 feet the bricks in the former are laid in mortar, while in the latter they are laid dry.

Bricks were also carried to the sites of 16 wells, and 7 of these have since been started.

57 The new boring apparatus is made on the system which has been found to work satisfactorily at Moradabad in sinking the wooden tubes through sand. For working in

wet sand a sludge pump is used, very similar in construction to that of a common suction pump. It consists of a cylinder with a valve at the bottom opening upwards. A piston with a valve in it, also opening upwards, moves up and down inside the cylinder, and a rope is attached to the end of the piston rod. The piston is made sufficiently heavy to sink by its own weight. When the piston is raised the foot valve of the cylinder opens, and sand and water are drawn into the cylinder. When the piston descends the foot valve closes, so that the sand cannot escape, while the valve in the piston opens, allowing the water to pass out. The piston is raised and lowered three or four times, in order to fill the pump with sand, the pump is then withdrawn and the sand cleared out. If the soil is hard it is first broken by means of a heavy jumper attached to the rope, and the debris is removed by the sludge pump. This system of boring has been used by Messrs Mather and Platt, of Manchester, in sinking artesian wells to depths of over 1,500 feet, and the deep boring at Umballa was made with their apparatus. It is especially useful for boring in wet sand, as the sludge pump is filled very quickly and removed at once by means of the rope, the heavy iron rods being entirely dispensed with. Two pumps should be used, one being worked while the other is being cleaned. As far as I have seen at present the system does not appear very suitable for getting through soft plastic clay, as the jumper works it up into "puddle," which cannot be removed by the sand pump. But if coarse sand is thrown down the bore before the jumper is worked, the clay is mixed with the sand, and lumps of the mixture are drawn into the pump.

58. In May, immediately after the receipt of the new tools, borings were made in two of the wells that had been sunk without reaching clay. In one well (in Jaithra) the mota was reached at a depth of 60 feet below the percolation level. In the second well (in Khirra Lagar Sahar) the pipes were sunk 75 feet without reaching clay, and as their total length is only 75 feet 6 inches, they could not go any deeper. They were therefore withdrawn.

59. Since then borings have been made in the 20 wells that were built 5 feet high and in nine more sites. The object being to ascertain whether a spring or a percolation well should be made, only 40 feet of tubing are used\*. If the pipes reach clay they are sunk into it until no sand is brought up in the sludge pump, and the jumper is then worked until it has penetrated 2 or 3 feet of the clay. If the clay prove to be thicker than this the pipes are withdrawn. If no clay is found, or only a thin stratum which cannot form an efficient "mota," the pipes are sunk 39 feet and then withdrawn.

In 22 out of the 29 borings clay has been reached within 25 feet from the percolation level, and at an average depth of 21 feet 3 inches. In the remaining seven the pipes were sunk to an average depth of 39 feet 1 inch below the percolation level without finding clay. Most of this work has been done since the rains commenced, and the percolation level has risen. The depth, therefore, from the normal percolation level to the clay is less than that given.

The 29 borings have cost Rs 76 for labor alone, or Rs 2-10 per boring. To this must be added the cost of ropes and an allowance for the wear and tear of tools and pipes. This should not exceed Rs 2, making the total cost of a boring less than Rs 5.

60. The result of the trial borings has been to show that in a great part of the tract where kucha percolation wells are now made by the cultivators a stratum of "mota" exists at a depth very favorable for the construction of masonry spring wells. This is shown in *Plate No II*. Up to the present "mota" has not been found in Khirra Lagar Sahar and Mahaya. It is found on the west side of Tigra Bhamora, and in about half of the land of Jaithra which is debarred from canal irrigation. In Bahgon it is found on both sides of the tract in which spring wells are made by the villagers. Borings are still in progress, and the map will require modification when their results are known.

It is interesting to note that the "mota" has been found either within 25 feet from

the percolation level, or not within 40 feet from it. It would appear, therefore, that the stratum which exists under a great part of the percolation well tract terminates abruptly. The sections obtained in three wells at *p*, *q* and *r*, are given in *Figs 9 to 11, Plate No. V*. The distance from *p* to *r* is only  $2\frac{1}{2}$  furlongs, but the three sections differ very much.

Since the borings have been made, work has been started again on the 20 wells that were built to a height of 5 feet, and 7 more wells have been started. Seven of these will be percolation wells, and the cylinders of twenty will reach clay.

61 Some new tools and pipes have been obtained for making deep borings in the 12 wells which have been sunk. One set of pipes, 120 feet long and 3-inch bore, was supplied by the Superintendent of the Canal Foundry, Roorkee, the other, 150 feet long and 2-inch bore, by Messrs T. E. Thomson and Co. of Calcutta. The pipes are connected by outside screwed couplings, rounded or bevelled, in order to reduce the resistance as much as possible. With each set of pipes three steel shoes have been supplied, so that six smaller sets can be made up, each long enough to ascertain if the "mota" is less than 40 feet from the percolation level or not. The sand pumps have been made by Messrs Coen and Co. of Agra.

Borings were commenced with these pipes early this month. The 3-inch pipes were put down one of the old wells in Jaithra, and reached clay at a depth of 55 feet below the percolation level. It was intended to ascertain the thickness of the "mota" by putting an Abyssinian tube well,  $1\frac{1}{4}$ -inch in diameter, down the 3-inch pipe and trying to drive it through the clay. But before the 3-inch pipes were properly bedded in the clay, a jumper got jammed in the lowest pipe, and as the rope broke it was necessary to withdraw the pipes.

They were then put down the well in Khirra Lagar Sahai, in which the old pipes had been sunk to a depth of 75 feet without finding clay. They have been sunk 80 feet below the percolation level and are still in sand.

The 2-inch pipes have been put down a well in Jaithra near the boundary of Khirra Lagar Sahai, and have been sunk 83 feet below the percolation level without reaching clay.

Thin seams of soft white clay have been passed through in all the deeper borings that have been made, but they offer little resistance to the passage of the tubes, and would certainly not form a good "mota". Strata of sand kankar and of nodular kankar have also been passed through. When the 2-inch pipes were sunk 45 feet below the percolation level, they went through a stratum of kankar, which was so compact that all the water was pumped out of the pipe without drawing any sand into it. If the kankar has a sufficient area to allow the cavity mentioned in para 24 to form below it, a good supply of water should be obtained. The sinking of the pipes has been continued below this stratum in order to ascertain the depth to the clay.

62 The present state of the work is as follows — 18 wells have been built and sunk, and six have reached clay. Two of the latter are in Jaithra and have been completed, the "mota" having been pierced, they are 6 feet in diameter. The remaining four are in Bahgon, and are 5 feet in diameter. They would have been finished before this but the gang of divers who sank them proved quite useless as soon as the wells reached clay, though they sank them through the sand without difficulty. The divers at Khwájapur will shortly have finished their work and will be sent to Bahgon.

Of the 12 wells that are in sand, five are 5 feet and seven are 6 feet in diameter. Borings have been made in three of the latter, and in two of them clay has been reached within 60 feet from the percolation level, while in the third the pipes have been sunk 80 feet without reaching clay. A pipe has been sunk 83 feet in one of the 5 feet wells without finding clay.

Judging from the positions of the wells, it is probable that clay will be found within 60 feet in five out of the seven 6 feet wells, but no idea can yet be formed of its depth in two of the 6 feet wells and in the five 5 feet wells. Owing to the clay stratum being so much deeper than was anticipated, the cost of these wells will be greater than was esti-



mated, but will be advisable to sink iron pipes 5 inches in diameter in all of the 6 feet wells. Pipes have been ordered for the two wells in which clay has been found.

As regards the 5 feet wells, only two buckets can work in them, and it is not worth while to spend much money on them. Unless clay or a compact layer of kankar is found within 20 or 30 feet from the bottom of a 5 feet well, an attempt will be made to get the water by percolation, and it is possible that sufficient water to supply two buckets can be obtained in this way.

63 The cylinders of 27 wells are being built, and 8 of them have been partially sunk. 20 cylinders will reach clay, 7 will be sunk 30 feet in sand, and will obtain their water by percolation. They cannot be sunk until the masonry is set.

64 Bricks have been carried to the sites of 12 more wells, and as soon as trial borings have been made the wells will be started. Until the tube and percolation wells that have been commenced have been finished and tested, it is proposed to confine the work to places where ordinary spring wells can be made.

The financial year of the Awa Estate closed at the end of last month, but the accounts have not yet been made up.

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## KHWAJAPUR CIRCLE.

### I. DESCRIPTION OF THE WELLS NOW USED.

65. The villages of the Khwájapur Circle are shown in *Plate No. III*. As previously stated, they are situated between the Sirsa and Domaria Nadis. The soil is generally light *pitha* or *bhúr*. A line of sand-hills runs through the villages, and much of the land is undulating. There is very little *usar*.

66. Among the sources of irrigation are the Patna jhil and the Sirsa nadi. Khwájapur is situated on the western border of the Patna jhil, and contains some of its tarai. About 200 acres of the village are assessed as irrigated from the jhil.

Shampur is bounded on the south-west by the Sirsa nadi. There is some tarai in the village, and 13 acres are assessed as irrigated from the nadi.

67. Some irrigation is done from two distributaries of the Ganges Canal. The Hardnagany Distributary passes through a corner of Chirgawan, and tails into the Sirsa nadi above Shampur. It irrigates a few fields in both of these villages.

The Lodhipur Distributary passes to the east of the villages, and irrigates a few acres in Khwájapur. A great part of the land in the Circle is too high to get irrigation from these rajbahas.

68. Wells form the main source of irrigation in all the villages, in Ataulahpur, Muhabatpur and Pasyapur. Begampur they are the only source. The depth from the surface of the ground to the level of sub-soil water varies from 15 to 30 feet. The water is generally sweet, but there are some brackish wells in Chirgawan.

A few of the wells receive their supply by side percolation, but most of them reach the "mota," and are supplied by springs.

The cost of a kucha well is stated by the villagers to be from Rs. 10 to Rs. 12, but from enquiries that have been made the actual cost to the cultivators appears to be about Rs. 6.

The kucha wells last two years at the furthest, most of them fall in the year they are dug.

None of them give water for more than one bucket, and in some wells the supply is not enough for this.

69. All the wells are worked on the *khi* system, two pairs of bullocks being employed to one bucket. The rope is attached to a loop on the yoke by means of a wooden pin (*khi*). When the bullocks get to the bottom of the run, the driver removes the pin and walks up the run holding the end of the rope. On reaching the top he finds a second pair of bullocks waiting there, and attaches the rope to their yoke. By the time the second pair of bullocks have got to the bottom of the run, the first pair have reached the top and are ready to go down again.

The buckets are large, containing from 26 to 36 gallons. The cattle are stronger than those used in the eastern part of the Etah District.

70. The following Table, taken from the Settlement papers, gives the areas of irrigated and dry land in six of the villages —

Name of Village	AREA OF		Total cultivated area	Total area.
	Irrigated land	Dry land		
	acres.	acres	acres	acres
Ataullahpur, .. ..	125	67	192	210
Ohirgawan, .. ..	1,022	183	1,205	1,297
Pasiyapur Begampur, .. ..	251	130	381	451
Shampur, .. ..	440	594	1,034	1,285
Khwájapur, .. ..	507	134	641	764
Zainpura, .. ..	260	285	545	604
	2,605	1,393	3,998	4,611

Rather more than a third of the cultivated land was assessed as dry

In his note on Zainpura, Mr MacConaghey states that "this estate is capable of much improvement if more cultivators were located and a few pukka wells sunk" The same may be said of other villages—especially Shampur and Ataullahpur.

## II. THE AREA IRRIGABLE FROM A WELL

71 Table III gives the area irrigated during the last rabi from some spring wells in the Khwájapur Circle The average area irrigated per bucket was 7 57 acres from pukka and 5 85 acres from kucha wells, the average for the whole being 6 15 acres

The villagers say that a pair of bullocks can irrigate 25 kucha bigahs, or nearly 5 acres of rabi crops. Hence one bucket worked by two pairs of bullocks should irrigate nearly 10 acres Doubtless this area can be irrigated if the well is constantly worked, but the greatest area recorded on a single bucket well is 8 8 acres

The average area irrigated from nine single-bucket pukka wells was 8 11 acres, and from three two-bucket wells it was 6 75 acres per bucket

8 5 acres appears a fair estimate of the area that can be irrigated from a single-bucket well in the rabi season, and a two-bucket well should irrigate 7 5 acres per bucket, or 15 acres altogether

72 The arguments used in paras 14 to 16 when discussing the area irrigable from a well at Jaithra apply equally to the Khwájapur villages A 6 feet well can take two large buckets, and should irrigate 15 acres of land in the rabi season The total area irrigable from a well of this size is 15 acres if the well is situated in gauhan or tarai land, and 30 acres if it is in the barha

In outlying lands the two-bucket well seems the best size to build, but in the gauhan and tarai lands a four-bucket well, 8 feet in diameter, will prove the most economical, provided the spring is powerful enough to supply it

73 It is interesting to note the difference between the area irrigable from a 6 feet well at Jaithra and from a well of the same size at Khwájapur

At Jaithra the *nagaur* system of working is adopted The cattle and buckets are small Four buckets can be worked in a 6 feet well One bucket irrigates 3 acres of rabi crops, and the well can irrigate 12 acres in a season

At Khwájapur the *lila* system prevails The cattle are stronger and the buckets very large Only two buckets can be worked in a 6 feet well, but one bucket worked by two pairs of bullocks can irrigate 7½ acres in the rabi season 15 acres can be irrigated from the well, or 25 per cent more than can be irrigated from a well of the same size at Jaithra.

### III. THE COST OF IRRIGATION.

74. The actual cost to the cultivators of making a kucha well is about Rs 6. The area irrigated by a well in the rabi is rather less than 6 acres (Table III). Most of the wells last only one year. Hence the cost of the well is about Re 1 per acre irrigated. In gauhan and tarai lands the cost is Re 1 per annum, in outlying lands it is 8 annas per annum.

In order to obtain a fair rate of profit from masonry wells, an enhancement equal to double these rates must be levied on the irrigable area. Therefore if pukka wells are built in places where kucha wells can be made, the cultivators must pay for the indirect advantages that will accrue from the wells, in addition to the direct gain they will receive by being saved the cost of making the kucha wells (para 18).

Many of the sites chosen are in places where kucha wells are not made, and then the question to be settled is simply the difference between the value of "wet" and "dry" land.

### IV. THE CONSTRUCTION OF MASONRY WELLS.

75. The "mota" appears to be very generally found in sinking wells in the Khwájapur villages, and it is probable that no percolation wells will be required. Most of the wells will be ordinary spring wells (*Fig 3, Plate No IV*), but in some places the "mota" may prove sufficiently thick to require a small shaft being sunk into it (*Fig 4, Plate No. IV*). A few tube wells (*Fig 5, Plate No IV*) may also be required.

76. The principles that regulate the construction of spring wells have already been discussed. One point, however, which has been mentioned in para 35, threatens to assume more importance at Khwájapur than it does at Jaithra. Where the strata permit it the cisterns should be 25 feet deep. But if the bottom of the "mota" is less than 30 feet below the percolation level, the depth of the cistern must be reduced. It is necessary to fix the minimum depth of cistern that may be allowed.

As mentioned in para 35 a great deal of uncertainty exists as to the depth the water will fall in a year of drought, and also as to the fall when the well is worked. By sinking the cylinder 25 feet below the ordinary percolation level, we allow for a fall of 21 feet when the well is worked during a dry year. If the cylinder is sunk only 15 feet, the water cannot fall more than 11 feet altogether, and this is the least amount of fall that should be counted on in a two-bucket well. Therefore no 6 feet wells should be built in places where the bottom of the "mota" is less than 20 feet below the percolation level. If any masonry wells are made in such places they should be 3 feet 6 inches or 4 feet in diameter, suitable for only one bucket.

No 8 feet wells should be built in places where the bottom of the "mota" is less than 30 feet below the percolation level, as the fall of water when four buckets are worked will be greater than when only two are employed.

I may mention that an experiment was started at Jaithra to determine the connexion between the discharge from a well and the fall of the water surface, but it was stopped by the early rain. The experiment will be made during the cold weather.

77. No borings have yet been made in these villages. The tools used at Jaithra are designed to work in sandy soil, and if the pipes are not stopped by kankar, lelwa, or clay, they are often sunk 25 feet in a day. But when the pipes reach clay the progress is very slow.

An Abyssinian tube well, with the driving apparatus used by the Royal Engineers, has been obtained from the Canal Foundry, Roorkee, but it has not yet been tried. It is probable that this tube, or a modification of it, will prove very useful for testing clay soils.

### V. THE COST OF MASONRY WELLS

78. In estimating the cost of the wells at Jaithra, the average length of the cylinder

above the percolation level has been assumed to be 14 feet. At Khwajapur it will be about 24 feet, or 10 feet longer.

If the cylinders are sunk to the same depth, the cost of the wells at Khwajapur may be found by adding to the estimated cost of the wells at Jaithra the cost of the additional 10 feet of masonry and of the extra earthwork required

If the cylinder is 6 feet in diameter and 12 inches thick, the cost of 10 feet in length is—

10 × Rs 4-6-6 =	..	..	..	Rs 44
Add for earthwork, establishment, &c,	..	..	..	16
Total Rs,	..	..	..	60

By making the cylinder 10 inches thick, the cost will be reduced to Rs 50

If the cylinder is 8 feet in diameter and 15 inches thick, the cost of 10 feet in length will be—

10 × Rs 7-4-2 =	..	..	..	Rs 73
Add for earthwork, establishment, &c,	..	..	..	22
Total Rs,	..	..	..	95

If the stemming is made 12 inches thick, the cost will be reduced to Rs 80

79. Adding these amounts to the figures given in para 42, we obtain the following results —

A 6 feet well costs from Rs 390 to Rs 425 according as the cylinder is 10 or 12 inches thick.

An 8 feet well costs from Rs 585 to Rs. 650 according as the cylinder is 12 or 15 inches thick.

As in the case of the Jaithra wells, the cost of an 8 feet well is about half as much again as the cost of a 6 feet well

80 A 6 feet well in the barha can irrigate 30 acres and if the enhancement is fixed at Re 1 per acre, an annual profit of Rs 30 will be obtained from the well. If the well costs Rs 425, the rate of profit will be 7 per cent

An 8 feet well in ganhan land irrigates 30 acres, and if the enhancement on the land is fixed at Rs 2 per acre, an annual profit of Rs 60 will be obtained. If the well costs Rs 655, the rate of profit will be 9.2 per cent

81 The cost of a spring tube well may be found by adding the cost of the extra 10 feet of the cylinder to the figures given in para 47

If the minimum rate of profit is fixed at 6 per cent, the cost of a 6 feet well must not exceed Rs 500, and of an 8 feet well Rs 1,000

## VI REPORT OF WORK DONE AND IN PROGRESS

82 Two 6 feet wells have been completed. One of them was sunk 22 feet and the other 17 feet when the "mota" was pierced. There are about 4 feet of clay below the curbs

Two 6 feet wells have been partially sunk. One cylinder, 7 feet 6 inches in diameter and 12 inches thick, has been built to a height of 30 feet, but has not been sunk. Six curbs of this size have been made, but the cylinders are hardly large enough for four large buckets, so the curbs are now being made 8 feet in diameter

Twenty-five wells have been dug to the percolation level, and all of them would have been started had not the brick-burning failed. Two contractors agreed to supply 5,00,000

bricks before the 31st May, at Rs. 12 per 1,000 for first class, and Rs 8 per 1,000 for second class bricks For bricks supplied after this date, the rates were to be reduced by Re 1 per 1,000 for each class of bricks Not more than 25 per cent of the total bricks supplied were to be second class The mean dimensions of the bricks is 12"  $\times$  6"  $\times$  3" The contractors moulded 5,00,000 and burnt 3,00,000, but by far the greater number of the latter have turned out *pila*, and out of the bricks intended for 6 feet cylinders, only enough to build four wells were obtained Most of these are second class, and the wells have therefore been plastered inside

Arrangements have been made to burn the bricks in Bull's kiln by petty contract and daily labor, and some wood on the canal has been purchased for the purpose As soon as the bricks are ready more wells will be commenced

W J WILSON,

14th October, 1882.

*Assistant Engineer on Special Duty.*

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TABLE I—Showing area irrigated from Spring Wells in some villages of the Jaithra Circle, Ara Estate, Faal Rabi, 1881-82

DESCRIPTION OF WELL.			Name of village.	Number of wells	Number of buckets.	Area irrigated in acres.	AVERAGE AREA IRRIGATED	
Pucka or Kucha.	Number of buckets worked on each well.	Depth from ground to water in well.					By one well.	By one bucket.
Pucka, ..	4	Feet 11 and 17	Bahgon, ..	2	8	14 35	7.18	1.79
, ..	4	12	Jaithra, ..	1	4	5 29	5 29	1 32
				3	12	19 64	6 55	1 64
" .	2	7 and 17	Bahgon, ..	5	10	18 93	3 78	1 89
		Total	Pucka wells, ..	..	22	38 57	..	1.75
Kucha, ..	2	10 and 14	Bahgon, ..	14	28	72 07	5 15	2 57
" ..	1	10 and 11	Bahgon, ..	11	11	31 24	2 84	2 84
" ..	1	12	Jaithra, ..	1	1	1 94	1 94	1 94
				12	12	33 18	2 77	2 77
		Total	Kucha wells, ..	..	40	105 25	..	2 63
			Grand Total, ..	.	62	143 82	..	2 82

TABLE II—Showing area irrigated from Percolation Wells in some villages of the Jaithra Circle, Ara Estate, Faal Rabi, 1881-82

DESCRIPTION OF WELL.			Name of village.	Number of wells	Number of buckets.	Area irrigated in acres	AVERAGE AREA IRRIGATED	
Pucka or Kucha.	Number of buckets worked on each well.	Depth from ground to water in well.					By one well.	By one bucket.
Pucka, ..	2	Feet 10 and 15	Jaithra, ..	3	6	16 15	5 38	2 69
" ..	1	9 and 11	"	15	15	54 10	3 61	3 61
" ..	1	13	Khuria Lagar Sahai, ..	1	1	1 23	1 23	1.23
				16	16	55 33	3 46	3 46
		Total	Pucka wells, ..	..	22	71 48	..	3 24
Kucha, ..	2	13	Jaithra, ..	1	2	2 05	2 05	1 02
" ..	2	11	Mahaya, ..	1	2	4 76	4.76	2 38
" ..	2	10 and 12	Khuria Lagar Sahai, ..	4	8	13 98	3 49	1.75
" ..	2	13	Tigra Bhamora, ..	2	4	15 15	7 57	3 79
				8	16	35 94	4 49	2 24
Kucha, ..	1	1 and 13	Jaithra, ..	216	216	600 79	2 78	2 78
" ..	1	10 and 13	Khuria Lagar Sahai	36	36	82 92	2 30	2 30
" ..	1	10 and 11	Mahaya, ..	16	16	54 19	3 38	3 36
" ..	1	9 and 11	Bahgon, ..	36	36	116 26	3 23	3 23
" ..	1	10 and 11	Tigra Bhamora, ..	14	14	42 48	3 03	3 03
				318	318	896 64	2 82	2.82
		Total	Kucha wells, ..	..	334	932 58	.	2 79
			Grand Total, ..	..	356	1,004 06	..	2 82

TABLE III.—*Showing area irrigated from Spring Wells in some villages of the Khwájapur Circle, Awa Estate East Rahr 1881-82.*

DESCRIPTION OF WELL			Name of Village.	Number of wells.	Number of buckets	Area irrigated in areas.	AVERAGE AREA IRRIGATED	
Pucka or Kucha.	Number of buckets worked on each well	Depth from ground to water in well					By one well.	By one bucket
		Feet						
Pucka, ..	2	24	Begampur, ..	1	2	13 30	13 30	6 65
" ..	2	28	Pasyapur, ..	1	2	14 38	14 38	7 19
" ..	2	15	Khwájapur, ..	1	2	12 81	12 81	6 40
				3	6	40 49	13 50	6 75
" ..	1	18	Rámpura, ..	1	1	8 25	8 25	8 25
" ..	1	12 and 16	Khwájapur, ..	4	4	32 92	8 23	8 23
" ..	1	31	Zainpura, ..	1	1	8 80	8 80	8 80
" ..	1	20 and 22	Churgawan, ..	2	2	16 18	8 09	8 09
" ..	1	21	Faridpur, ..	1	1	6 86	6 86	6 86
				9	9	73 00	8 11	8 11
			Total Pucka wells, ..	12	15	113 50	..	7 57
Kucha, ..	1	16 and 20	Rámpura, ..	5	5	34 57	6 91	6 91
" ..	1	18 and 27	Atanllahpur, ..	6	6	31 89	5 31	5 31
" ..	1	18	Pasyapur, ..	1	1	5 12	5 12	5 12
" ..	1	9 and 16	Khwájapur, ..	8	8	67 90	8 49	8 49
" ..	1	15 and 24	Churgawan, ..	21	21	107 13	5 10	5 10
" ..	1	13 and 23	Zainpura, ..	16	16	95 88	5 97	5 97
" ..	1	18 and 28	Faridpur, ..	15	15	78 68	5 24	5 24
			Total Kucha wells, ..	72	72	421 17	5 85	5 85
			Grand Total, ..	..	87	534 67	..	6 15

TABLE IV.—*Showing the loss of head in pipes of different diameters.*

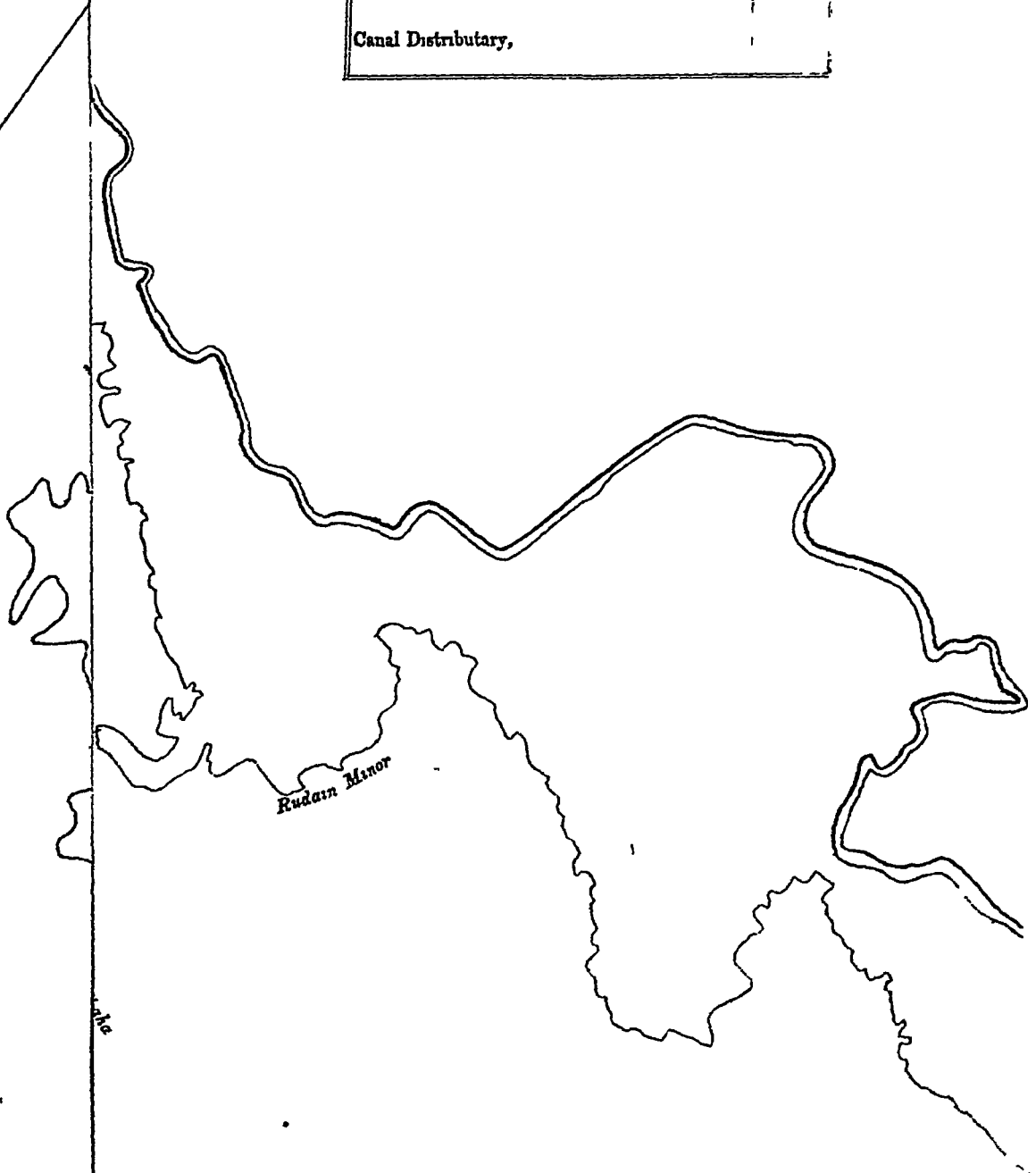
Diameter of pipe in inches.	Velocity of water in feet per second	Head due to velocity = $h$	Loss of head at the two ends of the pipe = $1.5 h$	Value of $c$ for incrustated pipes	LOSS OF HEAD DUE TO FRICTION IN			TOTAL LOSS OF HEAD IN	
					1 foot of pipe	50 feet of pipe	100 feet of pipe	50 feet of pipe	100 feet of pipe.
Discharge = 900 cubic feet per hour = 0.25 cubic foot per second									
3	5 10	0.40	0.61	0.0133	0.0857	4.29	8.57	4.90	9.18
4	2 87	0.13	0.19	0.0125	0.0191	0.96	1.91	1.15	2.10
5	1 84	0.05	0.08	0.0120	0.0060	0.30	0.60	0.38	0.68
6	1 28	0.025	0.04	0.0117	0.0024	0.12	0.24	0.16	0.28
12	0.32	0.002	0.002	0.0108	0.00007	0.004	0.007	0.006	0.009
Discharge = 1,200 cubic feet per hour = 0.33 cubic foot per second									
3	6 79	0.716	1.07	0.0133	0.1528	7.64	15.28	8.71	16.35
4	3 82	0.227	0.34	0.0125	0.0340	1.70	3.40	2.04	3.74
5	2 44	0.093	0.14	0.0120	0.0106	0.53	1.06	0.67	1.20
6	1 70	0.044	0.066	0.0117	0.0042	0.21	0.42	0.28	0.49
12	0.42	0.003	0.005	0.0108	0.00012	0.006	0.012	0.011	0.017
Discharge = 1,600 cubic feet per hour = 0.5 cubic foot per second									
3	10 19	1.61	2.41	0.0133	0.3428	17.14	34.28	19.58	36.72
4	5 73	0.51	0.77	0.0125	0.0765	3.83	7.65	4.60	8.42
5	3 67	0.21	0.31	0.0120	0.0240	1.20	2.40	1.51	2.71
6	2 55	0.10	0.15	0.0117	0.0094	0.17	0.34	0.62	1.09
12	0.64	0.006	0.009	0.0108	0.00027	0.014	0.027	0.023	0.036





# REFERENCES

Land debarred from Canal Irrigation,	
Ditto ditto ditto belonging to the Awa Estate,	
Dhak Jungle,	212 1/2 2 24- 26-2
Land flooded during the rains,	
Canal Distributary,	



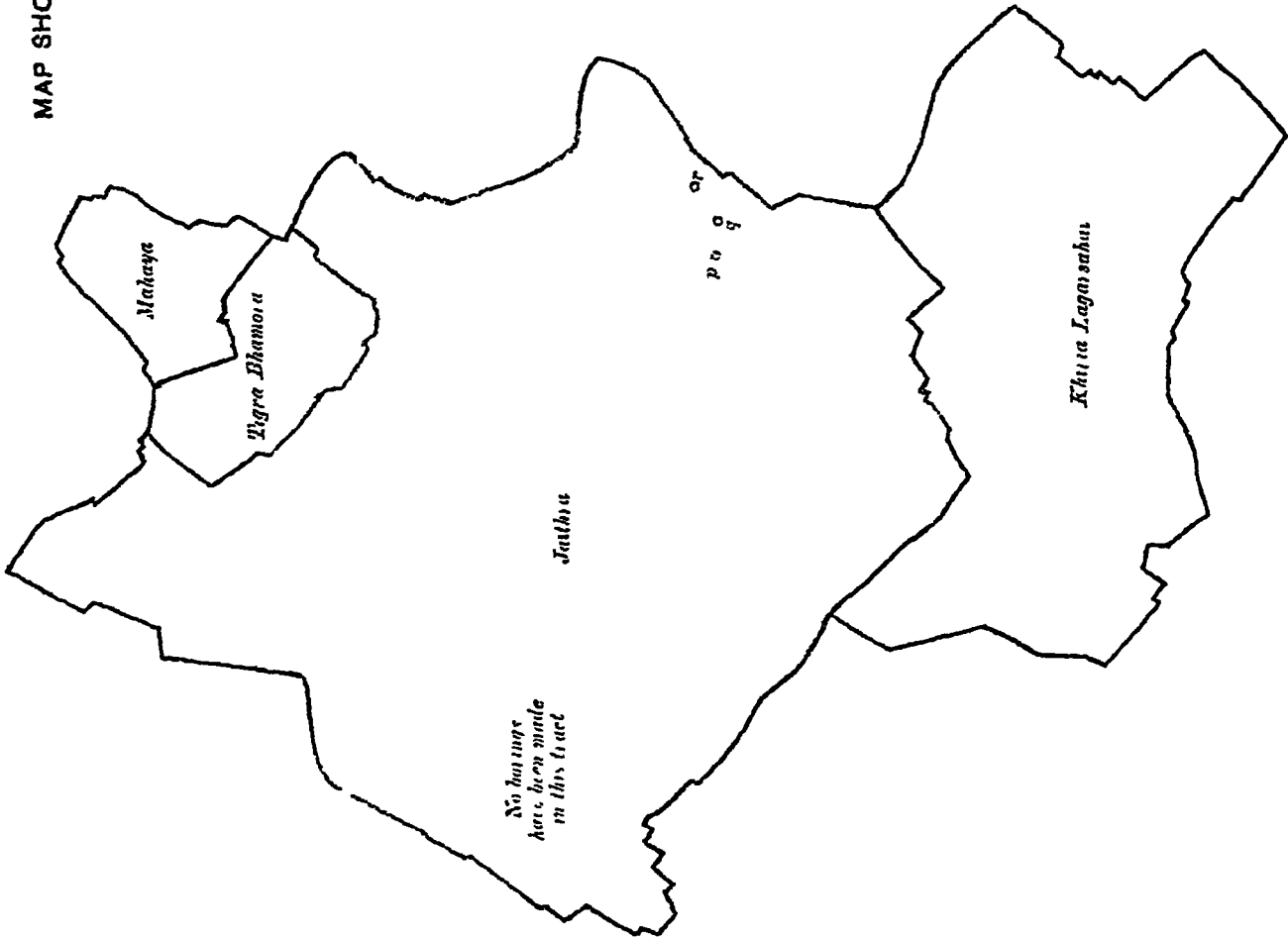
Rudain Minor



CONSTRUCTION OF WELLS IN THE AWA ESTATE.  
MAP SHOWING THE DISTRIBUTION OF "MOTA" IN PART OF THE  
JAITHRA CIRCLE.  
Scale, 1 1/2 Inches to 1 Mile.

REFERENCES

SPRING WELL TRACT		Land in which spring wells are made by the Villagers
PERCOLATION WELL TRACT		Land in which the "mota" is not more than 25 feet below the perco- lation level
		Land in which the "mota" is more than 40 feet below the percolation level

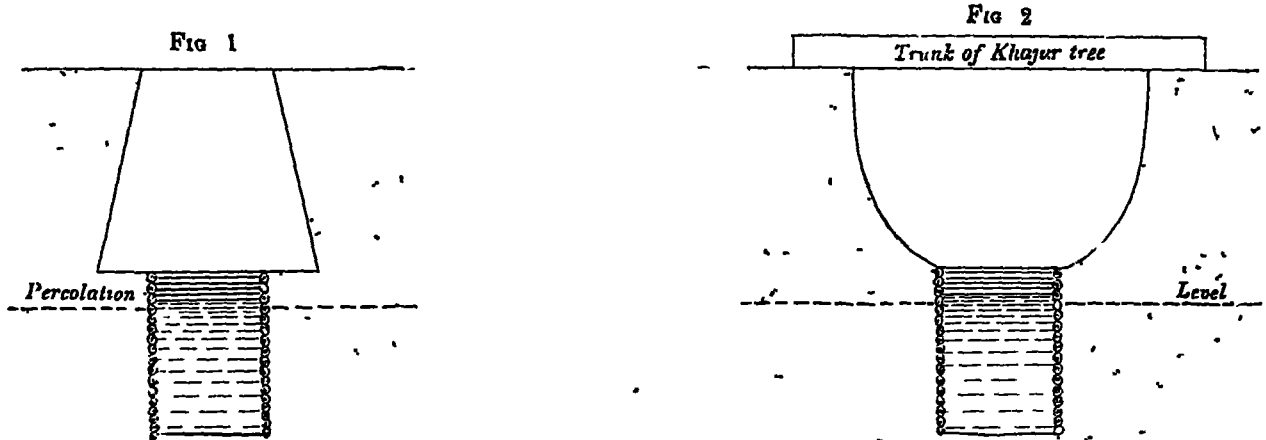




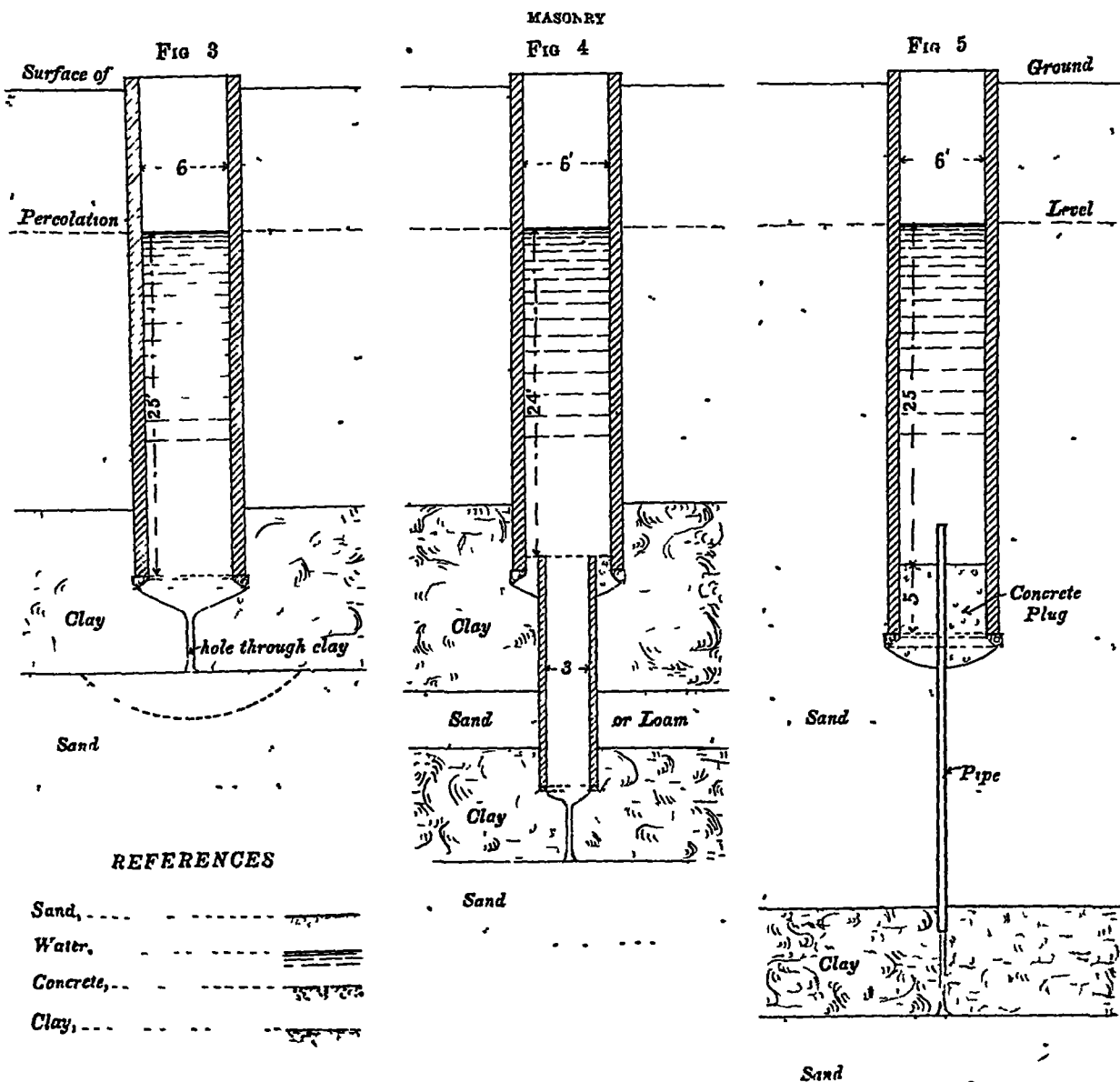
# CONSTRUCTION OF WELLS IN THE AWA ESTATE.

Scale, 12 feet to 1 Inch

## SECTIONS OF KUCHA PERCOLATION WELLS.



## SECTIONS OF SPRING WELLS.





CONSTRUCTION OF WELLS IN THE AWA ESTATE.

SECTION OF PERCOLATION WELL.

Scale, 15 feet to 1 Inch

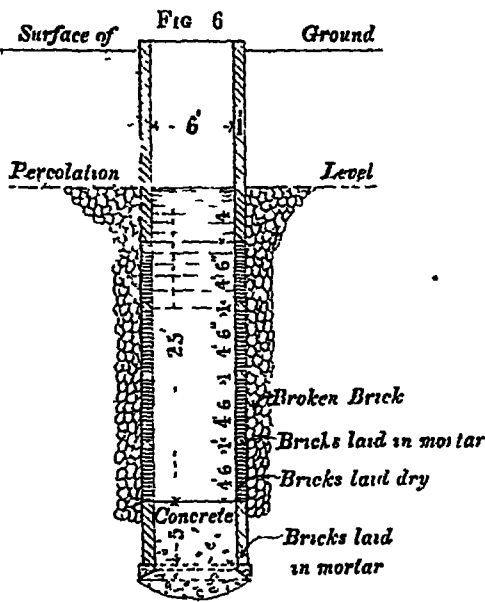
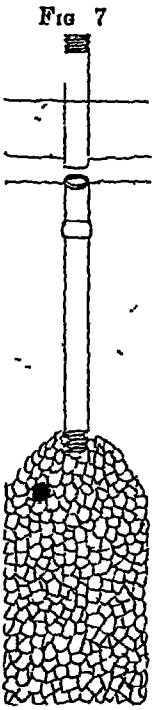


Fig 9  
2



SECTIONS OF SUBSOIL AT  
Pit 10  
q

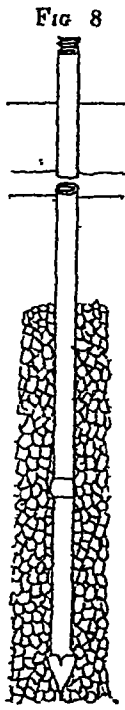
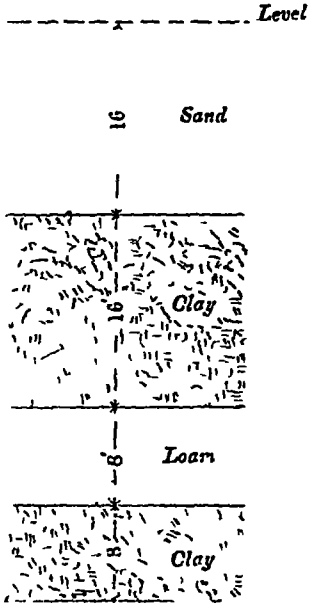
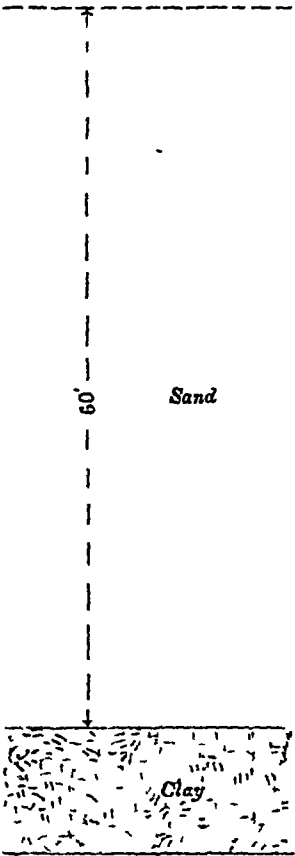
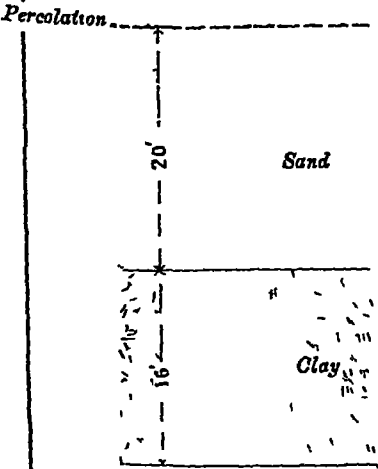


Fig 11  
r



REFERENCES

- Sand,
- Water,
- Concrete,
- Broken Brick,
- Bricks laid in mortar,
- Bricks laid dry,
- Clay,





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NOTE ON THE MORADABAD WELLS.

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# NOTE

ON THE

## CONSTRUCTION OF THE MORADABAD WELLS FROM THEIR INCEPTION IN DECEMBER 1879, TO THE TRANSFER OF MR. MEARES IN AUGUST 1882.

1. On the receipt of Mr. Wright's Report on the Construction of State Wells in Cawnpore, Mr. Buck in his covering letter to Government No.  $\frac{1300 A}{\text{CCXCXIII B}}$  of June 19th, 1879, urged that the experiments proposed by Mr. Smeaton in the Hasanpur pargana (Moradabad) should be carried out under Mr. Alexander's supervision, and that further experiments under the same supervision should if possible be made on some adjacent tract where water was near the surface.

2. The suggestion made by Mr. Smeaton in his No 858 of April 17th, 1879, was that a score or so of villages on the sandy plateau of Hasanpur should be provided with wells—

(1) —As a security against landlord rapacity and oppression.

(2) —As an insurance against famine. He further hoped that they might be the means of introducing a system of water-lift, which he had modified from an appliance in use in Southern and Central India. He found from actual experiment that whereas with the ordinary native lift only  $1\frac{1}{2}$  of an acre had been irrigated by 16 bullocks and 12 men in 12 hours from a depth of 19 feet, with his improved lift,  $2\frac{1}{2}$  acres could be watered from the same depth and the same time by 2 men and 2 buckets. The experiment was one which in itself demonstrated the necessity of making investigations which should throw more light on the elementary problems of well irrigation, as though, allowing  $2\frac{1}{2}$  inches for the depth of a watering, the results of the experiment with the native *churru*s were reasonable enough, to secure the result reported by Mr. Smeaton for his lift would require that each bullock should lift 83 foot tons per minute, or 56 horse-power, which is altogether incredible.

3 On November 10th, 1879, the Director of Agriculture was authorized by telegram from the Board of Revenue to settle details with Mr. Alexander, the Settlement Officer of Moradabad, and in a communication dated two days later, Mr. Buck reported to the Board that he had met Mr. Alexander, who would undertake the work in combination with Mr. Mills, an engineer of the Department of Public Works. In this letter, Mr. Buck asks for instructions as to whether he is to continue to exercise supervision over the work, and makes a suggestion, the full value of which seems at that time hardly to have been appreciated, i. e., that some attempt should be made to get boring tools which would show whether or no wells could be constructed.

4 On December 9th, 1879, Mr. Mills joined at Moradabad, and a few days later Mr. Alexander reported that the work of collecting materials had commenced. Rods, augers, pipes and a crab-winch were provided from Roorkee for boring operations.

5 The nature of the objects to be aimed at was described in some detail in Mr. Buck's letter of December 12th, 1879

The object of Government (he says) is to ascertain how in each locality wells can be most conveniently constructed, and what arrangements between cultivators and zemindars are most suitable. What is desired is that these experiments should enable Government to frame a scheme for general adoption. The special points on which information is wanted are—

- (1) —What rental return actually is obtained for the advantage of well irrigation.
- (2) —What area is irrigable from each well,
- (3) —What increase of revenue can be expected at next settlement, and on what terms should the assessment be made.

6. Details of construction were to be settled in consultation with the Engineer, and it was important to extend the experiments to tracts where water was nearer the surface than it was at Hasanpur. In a subsequent letter (January 3rd, 1880) Mr Buck insists that, as the experiments are not local but provincial, more than one kind of well shall be constructed. The Engineer should have full latitude to construct any kind of well that had a *prima facie* prospect of success. He again hopes that a tract may be found where water is much nearer the surface than at Hasanpur, and where cultivators, while willing to use them, are unable to construct permanent wells.

7. Mr Alexander on his part made a number of suggestions, the most important of which are found in his letter to Mr Buck of January 13th, 1880. He there proposes to build 50 (presumably) four bucket wells at an estimated cost of Rs 650 each, allowing nothing for cost of supervision. These wells were to be distributed into the following classes.—

(a) —Twenty wells—the zemindars were to buy them outright by payment of the cost of construction in a lump sum or by instalments, interest at 6 per cent being charged on outstanding balances.

(b).—Fourteen wells—the zemindars were to manage these and pay interest only on the cost of construction, with option of purchase at any time. In this case the interest was to be 8 per cent. payable for a minimum period of 20 years.

(c) —Eight wells. Government was to have the management, and the zemindars to guarantee Government a certain income as long as the wells were kept in working order. The income in this case was to be 5 per cent on the cost of construction, and as Government being the manager, would take all the increased rents secured by the wells, the zemindars would only be called on to pay the guarantee in the event of the wells proving a financial failure, a result of which there appears to have been no presentiment.

(d).—Eight wells were to be built as a pure speculation and without any guarantee. The two latter suggestions appear to be explained by a passage in a previous communication, in which Mr Alexander proposed that a certain number of wells was to be built for cultivators, and crop rates, analogous to those charged for canal water, collected by the Tahsildar. There is no suggestion as to how Government was to acquire the land. He urges that unless a large number is constructed, the experiment will be inconclusive, and adds: the main object will be gained if a certain tract is protected from famine and actual loss avoided, and that an all round return of 5 per cent would be very satisfactory.

8. Throughout the earlier stages of this experiment three entirely different and not easily reconcilable views of what was to be its aim seem to have held the ascendancy in turns.

(1) —The wells were to protect this particular tract from famine

(2) —They were to be made as a commercial speculation

(3).—They were to enable Government to ascertain by actual experiment on what terms and under what conditions it could build wells all over the Provinces

9. Mr. Buck applied for a grant of Rs 25,000 for the Hasanpur wells, and Rs. 5,000 for the wells which were to be constructed in a tract of high water level, and the Board

sanctioned Rs. 15,000 to be spent during the current year, instructing Mr. Buck to furnish an estimate of what would be required in the ensuing year for inclusion in their budget. They further directed that the rate of interest chargeable to zemindars should be  $6\frac{1}{2}$  per cent. This ruling was subsequently modified by Government, which authorized Mr. Alexander to charge at his discretion any rate between  $4\frac{1}{2}$  and  $6\frac{1}{2}$  per cent, provided that arrangements were made for the recovery of the principal within 20 years. In a letter dealing with this point Mr. Buck remarks that 5 per cent. will be too low a rate to charge for interest, as Government will undertake repairs.

10 On January 30th, 1880, Mr. Alexander was authorized by Mr. Buck to construct 25 wells in any case, and 25 more if they did not interfere with his project of building experimental wells on the tracts of high water level; and the experiment was thus commenced—in the joint charge of Messrs. Alexander and Mills, and under the general supervision of Mr. Buck.

11 The money advanced was placed, by the order of Government, at the credit of Mr. Alexander at the Moradabad treasury, and not at the credit of the supervising department. The Accountant General was directed to pass disbursements on the Settlement Officer's order.

12 Mr. Mills was in charge of the engineering part of the work for about five months. He fell ill, and went on leave some time in May 1880. The exact date of his giving over charge has never been ascertained. Of what was done during that period there is no very clear record, but I can say from what I learnt when at Amroha in October last, that there had been considerable activity in the direction of engineering experiment. The first difficulty to be encountered was one which has not even yet been overcome, and which while it has been fatal to the financial success of the undertaking, gives it its whole value as a pure experiment. It was found that, while the water level was very much higher than appears to have been anticipated, in fact so near the surface of the ground, that any experiments with wells at higher water levels were quite superfluous, in the great majority of cases no clay could be reached except at enormous distances, if at all, and it became abundantly evident that to construct a remunerative well on the ordinary principles was a sheer impossibility. It then occurred to Mr. Mills that an effective well might be constructed by sinking a masonry cylinder in the sand to such a depth as to allow for the free play of the bucket in periods of maximum exhaustion, and that the supply of water might be obtained through a tube sunk from the bottom of the well till it reached and pierced the clay stratum. To test these views a tube was sunk in an old and exhausted well belonging to Ghulam Chisti Khan, at Hasanpur, to a depth of 77 feet below the ground and 44 feet below the percolation level. At that depth it tapped the clay, and as an immediate result the well, which had hitherto been nearly empty, received a copious supply of water. Success seemed assured, and the only problem left to solve was the proper diameter of the tube, and the cheapest and most durable material. It was not till nearly two years later, in October 1881, that the experiment was discovered to be inconclusive.

13 As iron was too dear to be used with any prospect that a well built with it would pay interest on cost of construction, experiments were made with other materials. Segmental bricks, or clay tubes sunk inside an iron tube, which was afterwards to be withdrawn, were tried without success. Proposals were made to fill the iron pipe with coarse sand and then withdraw it, or to sink a very thin and inexpensive iron pipe and leave it in the well, with a clay pipe inside to strengthen it. Eventually it was determined to adopt a suggestion made by Mir Muhammad Muhsin Khan, the very intelligent zemindar of Amroha, to sink pipes of gular wood, which he bored at his own house by a very ingenious machine invented for the purpose by himself.

14 There is no clear record of the amount of work done during the five months when Mr. Mills was in charge. It appears that a large supply of bricks had been burned, a few borings been made, and, as mentioned above, the tube sunk in Ghulam Chisti's old well, and a considerable number of experiments made with different kinds of tubing.

15 On Mr. Mill's departure Mr. Alexander was left in sole charge without any professional assistance, except that of a native Sub-Overseer on Rs 25 per mensem, of whom

it was subsequently reported that he was old and inefficient, and had never done anything but desk work.

16 On May 25th, 1880, Mr. Alexander reported further difficulties on his side of the undertaking. The zemindars in many cases had stubbornly refused to enter into any engagements for the repayment of the money to be spent, and were willing if not anxious to see their tenants ruined. He made two new proposals. Either the cost of the wells should be made repayable in 12 yearly instalments, and made an addition to the revenue at which they had recently been assessed, or the zemindars should be compelled to collect crop rates from the tenants benefited by the wells, and receive a small percentage for their trouble. Mr. Wright, who then officiated as Director, forwarded the proposals with the remark that both at Cawnpore and in Moradabad zemindars showed an unconquerable objection to the construction of wells by the State, and a recommendation that compulsory measures should be resorted to. The Board, however, negatived both Mr. Alexander's proposals, and directed that where the zemindars agreed, bonds should be taken, and where not, the cases should be reported. They had already demanded Mr. Alexander's final Report and the Director's review of it.

17. The first regular Progress Report was sent in by Mr. Alexander on August 24th, 1880, and the state of the undertaking at that time was as follows.—Fifty wells had been projected—29 in Hasanpur—18 in Amroha, and 3 in Sambhal—of these one, the old well in Hasanpur Khas, of which mention has been made, had been completed, in two other old wells a tube had been sunk to nearly a sufficient depth; a fourth old well had been sunk to 18 feet beyond its original depth. Of the remainder, 15 or 16 feet of masonry had been built and sunk in three, the same height of masonry had been built but not sunk in 13, in 23 the bricks and curb were ready, the pits dug for most of them, and in some building commenced, in others delayed for want of lime. For three, the curb only had been made, for one other, the curb was being made of three, those in charge of the zemindar of Keshopur Bhundi, no details are given. The arrangements with zemindars were not fully completed, and are more fully reported in Mr. Alexander's next detailed communication.

18. In the same month Government gave the important ruling that the Engineer's pay was not to be charged to the Government advance for wells. A small sum, the exact amount of which was left to the Settlement Officer's discretion, was to be added on this account to the money repayable by the zemindars, as otherwise the real cost of construction would not be known, and one of the principal aims of the experiment would be defeated.

19. Mr. Alexander, with his assistant Mr. Darrah, had been in the constant habit all through the hot weather and rains, of driving to the well tract, the nearest point of which was 25 miles from the station, whenever a Sunday or holiday released them from the pressure of their regular work. But the wells themselves were scattered over a very large area, the best supervision a civilian could give would be little better than futile, and in answer to Mr. Alexander's urgent appeals Captain Bellasis was appointed, and took over charge of the engineering part of the work on December 25th, 1880.

20 On the first day of 1881, Mr. Carmichael visited Rajabpur, Hasanpur and Amroha, and inspected the wells which were in course of construction in that neighbourhood. He found that the question of material for tubing was still undecided. Iron, earthenware, and gular wood were all being tried at the same time in different wells. Natives were watching the experiment with interest, and Mr. Carmichael had no doubt that a large number of applications for wells would be the result if it succeeded. Mr. Carmichael indicated as the weak points of the experiment that Mr. Alexander had been under the mistaken impression that he was justified in resorting to compulsion, and that the wells were scattered over far too wide an area.

21. In connexion with this visit, Mr. Alexander drew up a second Progress Report explaining his action, and again commenting on the hostility of the zemindars, which he attributed mainly to what was no doubt one of the chief causes, the commutation of their tenants' rents from grain to cash payments, which was then in progress under his orders.

22. The arrangements for repayment of the money which was to be spent were as follows —

- (a) —For seventeen wells, Mir Muhammad Muhsin Khán engaged to pay the cost estimated after completion, provided that it did not amount to more than Rs. 400 per well, with 5 per cent on outstanding balances within 12 years Interest to run from the date of the bond
- (b) —Bonds had been taken from Ghulam Chisti Khán for nine wells. The period in this case was 10 years for three wells and 12 for the remainder, and there was a slight difference in the method of calculating the principal sum.
- (c) —In eight cases bonds were taken from the neighbouring cultivators who used the wells They were to repay the consolidated principal and interest in 20 years by annual instalments.
- (d).—In three cases annual water rates were accepted by the neighbouring cultivators
- (e) —The actual money advanced to the zemundar of Keshopur Bhindi was to be recovered in 15 years. Interest at 5 per cent and the principal being consolidated Government incurred no responsibility for the construction
- (f) —Four were Government property or in Court of Wards, and for one it had been found impossible to come to terms with any of the inhabitants, and Mr Alexander eventually paid its cost out of his own pocket.

23. At this time the distinction is at first clearly drawn between the (about) 25 which were being constructed by contractors under direct supervision, and the 20 which were being made under the superintendence of the zemindars. The latter were the 17 undertaken by Mir Muhammad Muhsin Khán, and the three in Sambhal

24. The Progress Report up to the time when Captain Bellasis took over charge shows the following results of the first year's operations on the wells under direct Government supervision —

- (a) —Completed with tube—one This was the old Hasanpur well.
- (b) —Cylinder completed and tube partly sunk—one
- (c) —Cylinder completely built and sunk but no tube—four
- (d) —Cylinder partly built and sunk—fourteen
- (e) —Bricks collected—four
- (f) —To be abandoned—one.

25. During the cold weather of 1881 Mr Alexander, who may be regarded as the originator of the experiment, and who had been in charge since its initiation, went on leave Captain Bellasis also left the work after he had been in charge for nearly four months, and the prosecution of the experiment was left to Mr Meares, the Executive Engineer of Moradabad, who took over charge from Captain Bellasis on April 17th, 1881

26. His first action was to send in a Progress Report which showed the following results for the wells under direct supervision

- (a).—Completely finished—one at Hasanpur.
- (b) —Cylinder finished and tube sunk to what might be a sufficient depth—three
- (c) —Cylinder finished and pipe partly sunk—two.
- (d) —Cylinder finished but no pipe—nine
- (e) —Cylinder partly built and sunk—seven
- (f)—Cylinder partly built but not sunk—two
- (g) —No work done—four

This list includes two wells which are not found in Mr Alexander's Progress Report They never advanced beyond the stage of collecting a few bricks.



27. Mr Meares retained sole charge of these wells till September 27th, 1881. When on his representation that his ordinary district duties interfered with their proper supervision, Mr Sub-Conductor Edwards was sent to take over the work under Mr Meares' orders.

28 During the last fortnight in October 1881 I inspected as many wells as were sufficiently advanced to admit of being tested in the company of Mr Wilson, the Departmental Engineer

The work up to that date had accomplished the following result.—

- (a) —Reported as completely finished—twelve
- (b) —Cylinder finished and clay pipe sunk and broken off—one
- (c) —Masonry finished and only tube wanting—four.
- (d) —Masonry partly built up and sunk—six
- (e) —Pit only dug—two
- (f) —Not commenced—two

29 The wells reported as finished were tested by Mr Wilson and myself by the simultaneous use for about  $1\frac{1}{2}$  to 2 hours in each case of a bucket holding about 25 gallons, and a Cawnpore farm pump The amount of water drawn was about 500 cubic feet in the hour, and in only one case did any well show signs of exhaustion As far as the water supply went the result was perfectly satisfactory, and showed the possibility of irrigating the area estimated by Mr Alexander, *ie*, between 20 and 30 acres for a two bucket, and between 40 and 50 for a four bucket well

30 Three only of the wells had reached the clay stratum One of these had not been sunk to a sufficient depth to provide a sufficient supply of water

The other two not only supplied ample water, but were perfectly free from any invasion of sand They were absolute successes

31 But in the remaining eight, which may be taken as typical of the wells over the whole tract, a defect was disclosed which does not appear to have been anticipated, and which, unless remedied, would prove fatal to their utility The cylinders rested on sand, which, when the water was drawn, rushed in, and filled them up to a depth which ranged from 2 feet 6 inches in a well which was only tested for nineteen minutes, to as much as from 4 feet 8 inches to 8 feet 3 inches in those which had been tested for longer periods It was not clearly ascertained how much of this sand came up through the pipe, but it was plain that the greater part, if not all of it, came from under the curb, and that the work of only a few days would leave the cylinders suspended over a vacuum in which they must very soon be engulfed

32 The first step necessary was therefore to plug up the bottom of the wells in such a manner as to exclude the sand When that had been done, it remained to be seen whether the pipe itself would not bring up sand enough to endanger eventually the safety of the wells Mr Meares, who accompanied us for the greater part of the time in which we were engaged on the testings, thought that a plug of kunkur in layers of graduated sizes might act as an effectual sieve, admitting water but excluding the sand This experiment was sanctioned, and on December 18th, 1881, at the suggestion of Captain Clibborn, I directed that the further experiment should be tried in one well at least of plugging it with an impermeable layer of concrete, thereby leaving the whole of the feeding to be done by the tube The tubing then being used was the gular wood pipe made by Muhammad Muhsin Khán, and of 5-inch diameter It appears to answer well, but it remains to be seen how it will stand the test of time

33 In December 1881, Mr Meares reported that he was not satisfied with the work done by Mr Sub-Conductor Edwards, and suggested that he should be sent to his ordinary duties, Mr Meares being relieved of his district duties and put in exclusive charge of the wells The arrangement was sanctioned, and came into effect in the beginning of February 1882

34 Early in February Mr Meares reported that he was in want of funds It was necessary to make some enquiries relative to his statement of accounts, but in the meantime

Rs 2,000 were sanctioned by the Board of Revenue in March to prevent the work coming to a standstill.

35 On April 14th I received an order from Government directing me to close the wells by the end of that month current. I ventured to give reasons why this order should be reconsidered, and received at once assurances that this should be done, assurances which were carried into effect by Government Order 715 of May 8th, 1882. In Government Order 967 of June 7th, 1882, it was ruled that the extra expense of Rs 600, which had been applied for by Mr Meares might be sanctioned on the understanding that the wells should be completed for that amount. But in the meantime the Board of Revenue had forwarded the earlier order direct to the Collector of Moradabad, with instructions that all work on the wells should be closed by April 30th. The first news I received of this was by a letter from Mr Meares informing me that he had already taken charge of district work. I at once addressed the Board, and on the urgent representations of both Mr Tracy and Mr Meares, it was agreed that he should retain charge of the wells as a part of his ordinary district work, an arrangement which had already been sanctioned by his Department when his connexion with them began a year before. Things remained on this footing till the middle of August, when a private communication from Mr Meares to the effect that he had been transferred from Moradabad was again the first intimation I received that the continuity of the experiment was threatened. He left the work under orders from the Chief Engineer some time in the last week of August, and this is a convenient date to bring the history of the experiment up to.

36 It remains for me to revert to the Engineering part of the operations. Early in April, Captain Clibborn visited the wells at my request, and reported that he had tested two wells. That at Bajohan, which had reached clay, and which was the only one except the old Hasanpur well, which Mr Wilson and I had found to be perfectly successful when we tested the wells in October, was subjected to a severe strain for nine hours and showed no signs of exhaustion or subsidence. Our conclusions were fully confirmed by this second trial, and it may be accepted as a complete success.

The second well, at Chak Dhanori, had been fitted with a ballast plug, and was, as Mr Meares told Captain Clibborn, fairly typical of the class of wells which had been sunk. This too was severely tested for nine hours, and the result proved conclusively that the ballast plug was useless as a sieve to pass water and stop sand. The well began to crack an hour after the drawing was commenced, and in five hours had sunk 1 foot 5 inches into the ground. Before the end of the trial it was choke full of sand, and no water came in except a little through the tube, and that, it is interesting to remark, was still perfectly clear and free from sand. The whole of the sand then must have come from under the curb through the ballast plug. The cylinder had subsided, leaving the ballast plug in its old position as far higher within the cylinder as the cylinder had sunk into the ground.

Captain Clibborn further reports, that Mr Meares found it beyond his power to bring the accounts from the beginning of the operations into an intelligible form.

37 On this report Mr Meares was again directed to try a concrete bottom, and the Examiner of Public Works Accounts was asked to put a trained accountant at his disposal for as long as the clearing of the accounts might require him. The accountant joined Mr Meares on May 1st, and submitted a detailed account on August 1st. I have omitted to say that in April, when the question of advancing more funds came up, I had directed Mr Meares to abandon two wells in which only a little work had been done up to that time. The number remaining under his direct superintendence was 23.

38 On May 4th, Captain Clibborn made a second inspection of the wells, and with Mr Meares sunk a concrete plug 4 feet thick in the bottom of the Chak Dhanori well, effectually closing all entrance either of water or sand except through the pipe. He further tested the Majhola well, in which Mr Wilson had found that though it reached the clay, the supply of water was insufficient. Since then the bottom had been strengthened and the pipe driven further in with the effect of entirely remedying its previous shortcoming. It gave 3,600 cubic feet in 6½ hours.

39 It took three weeks for the concrete in the Chak Dhansri well to harden, and on June 30th and 4th, four testings were made under Mr Meares' personal supervision. The results were as follows —

		Time.	Water drawn.	Deduct for reduced content of well	Delivered through tube.
1st testing,	..	1-15	441 c ft	308 c. ft	133 c ft.
2nd "	..	2-0	962 5 "	448 "	514 5 "
3rd "	..	3-0	906 "	450 "	456 "
4th "	..	1-5	619 "	448 "	171 "

The testing, especially in the fourth experiment, when 531 5 cubic feet were drawn in 50 minutes, was much more severe than previous experiments would have justified, but the result was not discouraging. No sand came into the well, and only 2 feet 6 inches into the 80 feet of tube. Neither tube nor cylinder were in the least disturbed. The only result which was not wholly satisfactory was that the water supply had been considerably diminished. The well, which was 6 feet in diameter and was intended for two buckets, only gave a discharge of about 1,500 cubic feet in the day, which is not more than what would be taken out by a single bucket by a not very efficient cultivator.

40 On June 29th, Mr Meares again went to the wells, and set testings going, which were continued for three days after he had returned to Moradabad. On the first day no sand came into the tube—on the second only trifling amounts. These experiments were conducted in his presence. On the fifth day (July 3rd), when he was not there, a most surprising result was reported—350 buckets, or about 1,225 cubic feet, were drawn in four hours, no sand came up while the water was being drawn, but when operations were suspended there was a sudden rush which filled up the tube and one foot of the cylinder. This extraordinary phenomenon is reported in a way which leaves much to be desired in the way of clearness, and I very much doubt whether it was correctly understood. It is possible that the fine sand suspended in the water of well left a sediment of one foot when the drawing stopped, which deceived the natives in charge of the experiment, and that the rush was merely a conjecture on their part.

41 The experiments were conducted till the 18th of July, chiefly under native supervision. The well was worked generally for four hours at a stretch, and fifty buckets (say 175 cubic feet) taken in the hour. Only a very few feet of sand came up the tube, and none into the cylinder. The result showed that, even if the report of July 3rd is to be accepted, and it is dangerous to work at the rate of 88 buckets to the hour, the well is perfectly safe with a draft of only 50 buckets to the hour, and that the limit to which it can be worked with safety is something more than 50, but less than 88, buckets to the hour.

This was the last experiment, and I have nothing further to report.

42 The position in which Government stands at this stage of the experiment is as follows —

It has 23 wells in pargana Hasanpur, in all of which the cylinder has been fully sunk, and tube sunk to as great a distance as seems necessary. Of these

One (1) in Hasanpur has long been an established success.

One (2) in Rajohan, }  
One (3) in Majhola, } have been lately proved successful

Two { (4) Padli,  
(5) Sahadra,

are reported to rest on clay and should therefore be successes, but they have not been tested

- Six { (6) Dehri Jat, No. 1,  
 (7) „ „ 2,  
 (8) Bahadurpur.  
 (9) Bawan Kheri, No. 1,  
 (10) „ „ „ 2,  
 (11) Rajohan, „ 2,

were tested in October 1881, and found to be unsafe Ballast or kunkur plugs have since been sunk in all, but testing has been deferred pending the results in Chak Dhanori

One (12) Chak Dhanori—the condition of this well has been reported in detail.

- Nine { (13) Karanpur, No 2,  
 (14) Ekonda, „ 1,  
 (15) „ „ 2,  
 (16) Baldana,  
 (17) Hashimpur,  
 (18) Hayatpur,  
 (19) Muhamdi,  
 (20) Manota,  
 (21) Rampur,

have not been tested, and it is supposed that their cylinders rest in pure sand. The pipes are reported to end in coarse sand and kunkur.

One (22) Karanpur No 1 has not been touched since it proved a complete failure in October 1881

One Sadhpur. I am told by Captain Chibborn that this well was tested in April by Mr Meares, and that the cylinder has parted 22 inches below the ground surface, making the well useless I have no official report on this, though I believe Mr Meares mentioned the occurrence in a D. O. letter.

43. Besides there are 17 in the charge of Muhammad Muhsin Khán in Amroha. He was showing considerable activity in the construction of these up to the time of last October's testing He then seems to have suspended operations till he saw the results of the efforts that were to be made to exclude the sand.

No report has been made relative to the three wells in Sambhal which were to have been built by the zemindar of Keshopur Bhundi.

44. On these wells bonds have been taken as described in para. 21 for the following —

(a).—Hasanpur, Karanpur Nos 1 and 2, Baldana, Hayatpur, Muhamdi, Ekonda Nos. 1 and 2, and Rampur, from Ghulam Ghisi Khán.

(b).—Bawan Kheri Nos 1 and 2, Chak Dhanori, Rajohan Nos. 1 and 2, Sadhpur and Padli, from the cultivators.

(c).—In Bahadurpur, Majhola, and Hashimpur, crop rates have been assessed on the cultivators.

(d).—The two wells in Dehri Jat are in the Court of Wards, and the well on Sahadra in Government property Mr Alexander has paid for the Manota well Rs 869-5-0—the total cost on that having been Rs 408-11-6

(e).—A bond has been taken from the cultivators for a well in Tigaria, which has been since abandoned

(f).—Bonds have been taken from Muhammad Muhsin Khán for the cost of seventeen wells, and the sum of Rs. 4,528-12-7 has already been paid on account.

(g).—Rs. 1,000 has been advanced to the zemindar of Keshopur Bhundi

45. The steps remaining to be taken appear to be the following :—

- (1). Careful testings should be continued at the Chak Dhanori well, and it should be ascertained how many buckets per hour can be drawn with safety. The Engineer in charge could be furnished with instructions as to how this testing might be accomplished. They are too long and too technical for this report.
- (2). Most of the tubes end in nodular kunkur. The reason for this was probably the difficulty of driving a wooden tube through such a stratum. But an iron pipe could easily be put down as a continuation of the present wooden ones. It has usually been found that a layer of nodular kunkur immediately covers a layer of clay. Trial borings might be made in the tubes of the Moradabad wells by Mr Wilson's sand pump, and if they proved that there was a clay stratum within a few feet of the end of the present pipes, the wells might probably be made perfectly efficient at a very small cost.
- (3). There are reasons for believing that both the water supply might be increased and the flow of sand diminished if the hollow formed under the end of the tube were filled with bits of kunkur and hard stone. This could easily be tried. The cylinder should be emptied as far as possible, and a man sent down to drop the kunkur into the tube. He should occasionally let a line down to see that the tube was not being filled up.
- (4). Wells 4 and 5 should be carefully tested. It is possible that nothing further need be done to them.
- (5). The ballast or kunkur plugs should be taken out from beneath the cylinders in wells 6 to 11, and impermeable concrete plugs substituted.
- (6). Wells 13 to 21 should be tested, care being taken not to subject them to such a strain as to endanger the stability of the cylinder. If, as will probably be the case, it is found that sand comes up from under the cylinder they too should be supplied with impermeable plugs.

It should be left to the Engineer in charge to say whether it would be worth while to repair the broken wells at Karanpur and Saanpur, or whether they should be abandoned.

46. There appears to be no reason why the agreements taken for the three first wells on the list should not be enforced. In every other case they should be held liable to revision until the well has been finally pronounced on. The terms then to be exacted would depend on the safe water supply. Perhaps a capital sum calculated on the rate of Re 1 for every cubic foot drawn during the hour would be a fair charge. That is to say, a well that would give a hundred buckets, each holding four cubic feet in the hour, would be worth Rs 400, of course the limit originally agreed on would never be exceeded.

47. I have made no proposals as to the course to be adopted with Muhammad Mohsin Khan. That can only be determined when the experiments now in progress on the wells under direct supervision have been pushed to completion. He shared the sanguine views entertained at the commencement of the experiment, and whatever has been achieved is largely due to his energetic co-operation. He deserves I think to be treated with much consideration.

48. The statement of expenditure is taken from the accounts furnished by the accountant who was deputed to draw them up in May last. Since the commencement of the work there have been five officers in immediate charge, and four different Directors of Agriculture. This, and the fact that, owing probably to the funds having in the first instance been placed by Government at the disposal of the officer in charge, and not included in the budget of this department, no monthly audit bills have ever been furnished, has added very greatly to the difficulty of clearing up the financial aspect of the experiment. This must be my explanation of the discrepancies which occur between the cost of the finished wells which I reported in December last, and the cost of the same wells now given by the accountant.

49. The whole sum advanced by Government has been Rs. 27,600, and against this the savings up to the time when the accounts were made up appear to have been as follows —

				Rs.	A.	P.
Cash in Engineer's hands, ...	.	..		53	15	4
Credit at Treasuries, ...	...	...	...	2,888	15	7
Lapsed, ...	...	...	..	2,403	14	0
Total Rs., ...				5,346	12	11

This would make the total expense to Government up to the same date Rs. 22,353-3-1, of which Rs 5,528-12-7 have been advanced to Muhammad Muhsin Khán and the Zemindar of Keshopur Bhindi, leaving Rs 16,824-6-6 as the sum spent on constructing the wells under direct supervision, on tools and plant, and on experiments. The amounts under each of these heads, as far as I can understand the accounts, have been as follows —

				Rs.	A.	P.
Construction, ...	...	...	...	13,314	8	7
Tools and plant, ...	.	..	..	2,449	11	8
Experiments, .	.	.	...	1,085	15	5
Total Rs, ...				16,800	3	8

Which leaves an unexplained balance of Rs 24-2-10.

50. As has before been pointed out, it is impossible to say how much of this sum may be recoverable when the work has been completed.

51. Mr. Meares has furnished me with an account of the sums expended under the superintendence of each officer during the time he was in charge. I have not been able to make it tally exactly with the other accounts, but it seems to be approximately accurate —

		Work.	Tools.
Mr Mills, (5 months,) ..	5,690	13 10	1,271 11 4
Mr. Alexander, (8 months,) .	5,412	4 3	456 3 6
Capt. Bellasis, (8½ months,) ..	2,426	5 0	187 11 3
Mr Meares, (10 months,) ...	3,509	13 10	470 1 7
Mr. Edwards, (4 months,) ..	1,146	14 11	124 0 0

52 It cannot be said that the present experiments throw any light on the cost of masonry for wells, and this is so well known already that the defect is hardly a matter for serious regret. The cost of sinking tubes is less generally known, and some details which were given me by Mr Meares in October last may be of interest. He found the cost per lineal foot to be as follows —

				Rs	A	P
Iron tubing, . .	.	...	...	2	0	7
Sinking, ...	.	...	...	1	14	0
Total Rs., ...				3	14	7
Wood tubing, . .	..	..	..	0	11	0
Sinking, . .	...	..	..	1	0	0
Total Rs, ...				1	11	0
Earthenware tubing, . .	...	...	...	1	10	4
Sinking, . .	...	..	..	3	0	8
Total Rs, ...				4	11	0

NAINI TAL, }  
3rd October, 1882. }

(Signed) W. C. BENETT,

Director

Number	Site of Well	Diameter	Depth to water sur- face	Height of cylinder	Length of tube	Cylinder rests on.	Pipe rests on.	Total Cost.						Secured by	Remarks
								Value origi- nally esti- mated			Total Cost.				
								Rs.	A.	P.	Rs.	A.	P.		
1	Karanpur I, ..	6' 0"	10' 0"	38'	7" 82' 0"	Sand	Clay	248	14	1	400	0	0	Bond, Ghulam Chisti Khán	An old well has been built up and sunk 18 feet and pipe put in.
2	Karanpur II, ..	8' 0"	13' 0"	41'	0' 73' 0"	Sand	Sand and kunkur	684	8	8	600	0	0	"	Not tested.
3	Ekonda I, ..	8' 4"	11' 0"	30'	7" 8' 0"	Sand	Kunkur	923	8	5	700	0	0	"	Not tested—kunkur stratum probably 9" thick.
4	Ekonda II, ..	6' 0"	10' 0"	30'	0' 20' 0"	Sand	Sand	413	10	10	400	0	0	"	Pipe in progress, May 1882—no test.
5	Saladra, ..	6' 0"	12' 6"	30'	0' Nil	Clay	Nil.	409	0	11	450	0	0	"	Clay bed 3 feet thick—no test.
6	Padi, ..	6' 0"	10' 0"	30'	0' 8' 0"	Sand	Clay	407	11	0	450	0	0	"	Clay 1 foot thick—no test.
7	Hashampur, ..	8' 8"	9' 0"	30'	0' 30' 0"	Sand	Sand and kunkur	911	12	1	450	0	0	"	Government property.
8	Sadhpur, ..	6' 1"	11' 8"	32'	5' 8' 7"	Ballast	Sand and kunkur	437	12	10	400	0	0	"	Bond, from cultivators.
9	Mulamdi, ..	7' 6"	11' 8"	31'	2' 27' 7"	Sand	Sand and kunkur	906	12	1	700	0	0	"	Bond, from cultivators.
10	Hayatpur, ..	8' 1 1/2"	12' 8"	32'	8' 27' 5'	Sand	Sand and kunkur	906	0	4	400	0	0	"	Bond, Ghulam Chisti Khán.
11	Majhola, ..	8' 2"	12' 0"	22'	8' 10' 0"	Clay	Clay	71 1/2	0	10	600	0	0	"	Do.
12	Baldara, ..	6' 0"	5' 5"	27'	7' 30' 0"	Sand	Sand and kunkur	518	3	4	400	0	0	"	Do.
13	Chak Dhanori, ..	6' 0"	9' 0"	30'	0' 55' 10"	Concrete	Sand	586	15	11	400	0	0	"	A good well.
14	Rajolan I, ..	6' 0"	12' 0"	30'	0' 4' 0"	Clay and ballast	Clay	385	12	0	400	0	0	"	Not tested.
15	Rajolan II, ..	6' 0"	10' 3"	31'	3' 36' 0"	Ballast	Sand and kunkur	464	15	0	400	0	0	"	Under experiment.
16	Bawan Kheri I, ..	5' 0"	10' 0"	31'	3' 54' 0"	Ballast	Sand and stone	448	12	5	400	0	0	"	Good well.
17	Bawan Kheri II, ..	5' 0"	10' 1"	31'	2' 44' 0"	Ballast	Sand and kunkur	440	1	7	400	0	0	"	Tested—sand came into cylinder.
18	Bahadurpur, ..	6' 0"	10' 4"	31'	0' 27' 1"	Ballast	Sand and kunkur	414	15	7	400	0	0	"	Do.
19	Dehri Jat I, ..	6' 0"	9' 3"	32'	3' 28' 0"	Ballast	Sand and kunkur	512	4	8	400	0	0	"	Do.
20	Dehri Jat II, ..	6' 0"	9' 6"	31'	0' 55' 9"	Ballast	Sand and kunkur	477	8	4	400	0	0	"	Do.
21	Rampur, ..	8' 2"	23' 4"	43'	8' 51' 6"	Sand	Sand and kunkur	1,180	10	2	700	0	0	"	Do.
22	Manola, ..	6' 0"	14' 0"	32'	10' 10' 4"	Sand	Clay and kunkur	408	11	6	450	0	0	"	Do.
															Never tested—on high sandy ridge.
															Clay stratum 9" thick—never tested.

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TABLES AND APPENDICES TO CAPTAIN  
CLIBBORN'S REPORT.

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**TABLE A --- Observation and Experiment.**

Serial Number	Locality		Area in Acres			Cultivated Area			Percentage of Total Cultivated Area.										Irrigation Wells			Lifts			Average area per lift, in acres		Remarks							
	Village	District	Actual area in acres.	Percentage uncultivated		Percentage of actual area cultivated.	Double cropped area in acres	Total area actually cultivated in the year	Kharif				Rabi				Lame masonry	Dry bricks.	Kacha.	Leather bucket.	Earthen pots.	Total	Usual labor for lifting buckets.	Kharif.	Rabi.	Total								
				Wet.	Dry.				Wells.	Canals.	Other sources.	Wet.	Dry.	Wells.	Canals.	Other sources.												Wet.	Dry.	Total				
1	Jayman, ..	..	879	26.5	28.1	45.4	..	356	12	13	14	16	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	No of lifts doubtful
2	"	..	879	26.5	28.1	45.4	..	356	12	13	14	16	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	"
3	"	..	879	26.5	28.1	45.4	..	356	12	13	14	16	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	"
4	"	..	879	26.5	28.1	45.4	..	356	12	13	14	16	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	"
5	"	..	879	26.5	28.1	45.4	..	356	12	13	14	16	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	"
6	"	..	879	26.5	28.1	45.4	..	356	12	13	14	16	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	"
7	"	..	879	26.5	28.1	45.4	..	356	12	13	14	16	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	"
8	"	..	879	26.5	28.1	45.4	..	356	12	13	14	16	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	"
9	"	..	879	26.5	28.1	45.4	..	356	12	13	14	16	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	"
10	"	..	879	26.5	28.1	45.4	..	356	12	13	14	16	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	"
11	"	..	879	26.5	28.1	45.4	..	356	12	13	14	16	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	"
12	"	..	879	26.5	28.1	45.4	..	356	12	13	14	16	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	"
13	"	..	879	26.5	28.1	45.4	..	356	12	13	14	16	16	17	18	19	20																	

TABLE A.—Observation and Experiment—(Continued).

DESCRIPTION.

Date				Class		Cost.					Supply.		Quality		Substratum		Cultivators on well		Labor and cost per day in annas.					
Serial Number				Number of Well.		Construction.	Fixings.	Total.	Renewal.	Extra.	Yearly repairs.	Total.	Do hired		Male, per day		Cattle		Cost for men.		Do. for cattle		Total cost, per day	
Day	Month	Year		41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
229	11	81		431	Dry brick,	200/-	8/-	208/-	20/-	7/-	1/-	11/-	Spring,	Sweet,	Clay,	1	Ahir,	1	30	75	106	75	106	
230	12	81		587	Kacha lined,	20/-	4/-	24/-	2/-	6/-	7/-	13/-	Percolation,	"	Sand,	2	"	2	20	70	15	70	15	
231	1	82		..	"	15/-	5/-	20/-	1/8	5/-	2/-	8/8	"	"	"	1	"	1	20	30	50	30	50	
617	12	81	28	16	"	22/-	8/-	70/-	5/-	5/-	4/-	19/-	Spring,	"	Clay,	2	Badamla,	2	40	60	120	60	120	
9	..	..	28	46	"	22/-	8/-	30/-	5/-	5/-	1/-	19/-	"	"	"	2	Chamar,	2	30	60	90	60	90	
11	..	..	28	42	"	22/-	8/-	30/-	5/-	5/-	4/-	19/-	"	"	"	2	" & Thakur,	2	60	60	120	60	120	
12	..	..	28	40	"	22/-	8/-	30/-	5/-	5/-	4/-	19/-	"	"	"	2	"	2	30	60	90	60	90	
13	..	..	30	77	Masonry,	300/-	12/-	312/-	..	5/-	1/-	16/-	"	"	"	5	Kachi,	5	60	90	150	90	150	
16	23	11	81	400	" 2 pur,	200/-	4/-	204/-	..	5/-	1/-	6/-	Percolation,	"	Sand,	1	Karni,	1	20	45	65	45	65	
17	18	12	81	218	" 4 pur,	200/-	4/-	204/-	..	5/-	1/-	6/-	"	"	"	1	Mahajan,	1	20	45	65	45	65	
20	16	12	81	706	" Masonry, old bad,	200/-	6/-	206/-	..	5/-	1/-	6/-	Spring,	"	Clay,	1	Kachi,	1	20	45	65	45	65	
21	..	..	..	..	"	100/-	2/-	124/-	..	5/-	1/-	6/-	"	"	"	2	Ahur,	2	20	45	65	45	65	
22	..	..	..	..	"	100/-	2/-	124/-	..	5/-	1/-	6/-	"	"	"	2	Chamar,	2	20	45	65	45	65	
23	..	..	..	..	"	25/-	4/-	29/-	..	5/-	1/-	6/-	"	"	"	1	Kachi,	1	20	45	65	45	65	
238	16	4	82	833	Kacha, lined with wood,	25/-	4/-	29/-	..	5/-	1/-	6/-	"	"	Clay 75,	1	Henduman,	1	20	45	65	45	65	
239	16	1	82	859	"	25/-	4/-	29/-	..	5/-	1/-	6/-	"	"	"	1	Kachi,	1	20	45	65	45	65	
242	24	11	81	..	Masonry,	310/-	4/-	214/-	..	5/-	1/-	6/-	"	"	"	3	Karni,	3	20	45	65	45	65	
262	27	11	81	3,850	"	300/-	6/-	306/-	..	5/-	1/-	6/-	Percolation,	"	"	1	"	1	20	45	65	45	65	
27	..	..	..	..	"	300/-	7/-	307/-	..	5/-	1/-	6/-	"	"	"	1	"	1	20	45	65	45	65	
29	20	11	81	345	"	200/-	3/-	203/-	..	5/-	1/-	6/-	"	"	Rock,	2	"	2	20	45	65	45	65	
31	10	11	81	1,446	"	200/-	7/-	207/-	..	5/-	1/-	6/-	"	"	Gravel,	1	"	1	20	45	65	45	65	
32	11	12	81	1,650	"	250/-	6/-	256/-	..	5/-	1/-	6/-	"	"	"	2	"	2	20	45	65	45	65	
33	21	12	81	200	"	200/-	5/-	205/-	..	5/-	1/-	6/-	"	"	"	1	"	1	20	45	65	45	65	
34	4	12	81	320	"	100/-	3/-	103/-	..	5/-	1/-	6/-	"	"	"	1	"	1	20	45	65	45	65	
35	4	12	81	3,001	Kacha,	5/-	0/-	5/-	old.	5/-	1/-	6/-	"	"	"	1	"	1	20	45	65	45	65	

TABLE A — Observation and Experiment—(Continued)

EXPERIMENTAL																			
COMMAND										AREA IRRIGATED TO DATE									
Kharif 1881-82										Rabi 1881-82									
Serial Number	Class.	Pairs of cattle to each lift.	Lift		Depth to Wells		Soil	Kharif 1881-82					Rabi 1881-82						
			Number	Content in cubic feet.	Morning	Evening		Mean.	Crop.	Waterings required	Area	Total area reduced to one watering	No of days to area.	Crop.	Waterings required	Area.	Total area reduced to one watering	No of days to area.	
62		63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1	Lager,	1 25	2	3 00	42	38	40	Dumat,	Cotton,	2	32	64	68	Wheat & Barley,	3	35	105	103	..
2	"	1 1	1	1	38	..	..	"	"	2	16	32	59	Wheat,	3	33	99	183	..
3	"	1 1	1	1	..	..	..	"	"	2	185	37	76	..	3	2 65	7 93	163	..
4	"	1 1	2	..	..	..	32	"	"	..	..	..	..	{ Wheat, Opium,	4	3 85	15.4	92	..
5	"	1 1	3	..	..	..	..	"	"	..	..	..	..	..	5	1 22	128	74	..
6	"	1 1	2	..	..	..	86	"	"	..	..	..	..	{ Wheat & Barley,	2	2 45	30	48	..
11	"	1 1	2	..	..	..	37	"	"	..	..	..	..	Wheat,	3	1 00	105	84	..
12	"	1 1	2	..	..	..	37	"	"	..	..	..	..	Opium,	3	2 90	238	78	..
13	"	1 1	3	..	..	..	35	"	"	..	..	..	..	Wheat,	2	2 28	31 00	78	..
14	"	1 1	3	..	..	..	..	"	"	..	..	..	..	{ Bajra,	3	3 45	..	..	..
15	"	1 15	1	..	29	..	..	Matyar,	"	..	..	..	..	Gujar,	2	31	62	87	..
17	"	1 1	1	1 875	91	94	42	"	"	..	..	..	..	"	..	Small,	..	..	..
18	"	1 1	1	2 925	15	16	15 5	Dumat,	"	..	..	..	..	Vegetables,	2	1 5	30	87	..
20	"	1 1	1	2 6	18	23	19 5	"	"	..	..	..	..	Wheat,	2	1 5	30	87	..
21	"	1 1	2	2 6	16	20	19 5	"	Cotton and Indigo	2	40	80	22	Wheat & Barley,	2 5	12 2	30 5	85	..
22	"	1 1	1	2 61	17	50	43 5	"	"	..	..	..	..	{ Potatoes,	12	0 5	40	224	..
23	"	1 1	1	..	..	..	..	"	"	..	..	..	..	Tobacco,	12	10	..	..	..
533	"	1 1	1	2 59	18	57	55 5	"	"	..	..	..	..	Garden,	8	1 6	..	..	..
24	"	2 2	1	..	..	..	..	"	"	..	..	..	..	Wheat,	4	1 5	40 8	216	..
25	"	1 1	2	3 0	30	40	36	"	"	..	..	..	..	Tobacco,	12	17	100	320	..
26	"	1 1	2	3 0	30	40	36	"	"	..	..	..	..	Opium,	5	2 0	22 8	250 8	..
27	"	1 1	1	..	31	..	..	"	"	..	..	..	..	Do & Vegetable,	10	0 90	90	69 3	..
28	"	1 1	1	3 0	20	23	21 5	Rakur,	Cotton,	2	2 6	5 2	20 8	Vegetables,	10	2 6	26 0	100	..
31	"	2 2	1	1 65	16	28	29	"	"	..	..	..	..	Tobacco,	7	2 88	198	79 2	..
32	"	1 1	2	2 12 7	20	28	31 5	"	"	..	..	..	..	Tobacco,	10	4 00	40 0	103	..
33	"	1 1	1	2 8 15	29	35	32	"	"	..	..	..	..	Tobacco,	10	4 00	40 0	103	..
34	"	1 1	1	2 06	10 5	14	12 5	"	"	..	..	..	..	Barley,	6	20	120	68 6	..
35	"	1 1	1	1 5	19	20	19 5	"	"	..	..	..	..	Barley,	6	4 7	28 2	197 4	..
										* No Kyaries									

TABLE A.—*Observation and Experiment—(Continued).*

**CONFIDENTIAL**

Serial Number.	Work										Cost.					Remarks									
	Duration of work minutes.	No. of lifts.	Cubic feet lifted			II P		Area irrigated			Depth		Days to an Acre				Annual		Per Acre.						
			Per pair of cattle per hour	Per lift, per hour	Total per well.	Per bullock.	Total per well.	Length of water course.	Crop	Watering	Interval	Area in square feet	On area.	Of damp.	Per pair of cattle.		Per lift.	Per well.	Duty per pair	Interest at 5 p c	Repairs, &c	Total	Per acre irrigated.	Yielding	Total
92	98	95	98	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116		
2	400	430	77 4	1,200	878	351	200	Wheat,	1	..	4,410	292	215	196	98	..	10 1/2	11 0/2	214	30	102	212	Wheat		
3	..	..	..	..	..	..	100	Paleo,	1	..	2,380	..	186	185	185	..	12 1/2	12 0/2	132	26	174	200	"		
5	..	..	..	..	..	..	..	Wheat,	1	..	2,100	..	207	207	207	..	1 0/2	8 5/2	95	21	194	215	"		
8	..	..	..	..	..	..	..	Mixed,	1	..	7,300	..	120	120	60	..	1 5/2	190	205	35	180	215	"		
9	..	..	..	..	..	..	..	Mixed,	..	..	7,161	..	116	116	58	..	1 5/2	190	205	37	163	200	Opium.		
11	..	..	..	..	..	..	..	Wheat,	1	..	5,476	..	160	160	80	..	1 5/2	190	205	117	180	102	Wheat and Barley		
12	..	..	..	..	..	..	..	Wheat,	1	..	5,500	..	160	160	80	..	1 5/2	190	205	38	135	171	Wheat.		
13	..	..	..	..	..	..	..	Opium,	1	..	17,706	..	75	75	25	..	15 5/2	100	310	24	120	144	Opium		
16	..	..	..	..	..	..	..	Closed with sluice	..	..	3,000	..	215	143	140	..	10 2/2	60	102	34	114	118	Gujar		
17	..	..	..	..	..	..	..	Opium,	1	..	4,000	..	110	110	110	..	15 2/2	60	212	..	234	..	Opium		
18	460	207	50 0	380	1 35	928	100	Vegetables,	1	3 days,	4,762	09	90	90	90	..	15 1/2	80	181	..	280	..	Vegetables		
20	540	390	126 0	1,140	520	281	400	Wheat,	1	..	1,198	60	290	290	290	..	10 1/2	70	178	75	214	31 1/2	Wheat		
21	530	776	111 2	114 2	4,084	700	300	"	1	..	15,705	138	55	55	28	..	21 2/2	250	462	28	47	75	Wheat (Cost calculated at 1 day per acre for 10 days' work)		
22	530	776	114 2	114 2	..	366	1,150	"	1	..	1,442	..	600	600	300	..	21 2/2	250	462	28	47	75	Wheat (Cost calculated at 1 day per acre for 10 days' work)		
28	527	381	115	1,014	1 567	826	270	Tobacco,	12	12 days,	7,550	13	75	56	56	..	1 5/2	60	72	14	168	26 1/2	Potatoes		
33	530	450	133	1,181	2 001	1,110	160	Tobacco,	10	12 days,	8,105	11	70	53	53	..	1 5/2	60	72	14	168	26 1/2	Tobacco		
24	480	..	..	..	..	..	1,000	Paleo,	1	..	1,357	..	220	320	320	..	10 7/2	40	117	149	..	..	..	Cannot be calculated	
26	..	..	..	..	..	..	100	Paleo,	1	..	3,920	..	220	220	110	..	15 3/2	90	243	39	..	..	..	Cannot be calculated	
27	..	..	..	..	..	..	100	Opium,	..	..	5,689	..	77	77	77	..	15 2/2	50	202	134	230	30 4	Opium		
29	105	122	214	372	1 285	175	350	Vegetables,	..	..	2,700	180	150	150	150	..	10 2/2	50	152	20	47 0	49 0	Garden		
31	275 1/2	414	74 55	149 1	983	580	200	Tobacco,	..	..	5,705	119	80	40	40	..	10 2/2	40	142	33	140	17 1/2	Tobacco		
32	452	1,009	162 0	102 0	2,447	1 117	507	"	2	..	17,020	148	512	512	256	..	12 8	90	218	30	128	164	"		
33	465	458	166 0	166 0	1 885	1 576	250	Barley,	2	..	7,551	170	577	577	577	..	10 2/2	50	152	31	180	164	"		
34	410	553	107	1,179	629	252	150	Barley,	1	..	8,286	187	53	53	53	..	10 2/2	40	92	31	96	137	"		
35	596	557	130	533	717	276	130	Barley,	1	..	6,020	138	70	70	70	..	0 4	40	44	0 6	152	158	"		

TABLE A.—*Observation and Experiment—(Continued).*

[illegible]

TABLE A.—Observation and Experiment—(Continued)

## DESCRIPTIVE

Serial Number	Date		Class.	Cost					Supply	Quality	Substratum	Cultivators on well		Labor and cost per day in annas.											
	Month	Year		Construction.	Pittings.	Total	Renewal	Lifts				Yearly repairs.	Total	Number	Casto.	Men, home.	Do. hired	Rate, per day	Cattle	Cost for men	Do for cattle.	Total cost, per day			
37	05	90	42		43	44	45	46	47	48	49		50	51	52	53	54	55	56	57	58	59	60	61	
36	06	1281	Masonry,	250/-	8/-	258/-	..	..	3/-	1/-	4/-	Gravel,	Percolation,	Sweet,	..	1	Kachi,	..	3	..	..	..	..	..	..
37	..	..	"	250/-	8/-	258/-	..	..	3/-	1/-	4/-	"	"	"	..	1	Lochi,	..	3	..	..	..	..	..	..
38	..	..	"	150/-	3/-	153/-	..	..	..	..	..	"	"	"	..	..	Kachi,	..	5	..	..	..	..	..	..
39	..	..	"	..	..	..	..	..	..	..	..	"	"	"	..	..	"	..	..	..	..	..	..	..	..
40	..	..	"	200/-	8/-	208/-	..	..	8/-	1/-	4/-	"	"	"	..	1	"	..	3	..	..	..	..	..	..
41	5	1281	"	150/-	0/-	150/-	..	..	3/-	1/-	7/-	Rock,	"	"	..	1	Brahman,	..	4	..	..	..	..	..	..
42	5	1281	"	150/-	0/-	150/-	..	..	3/-	1/-	7/-	Gravel,	"	"	..	2	Kachi,	..	4	..	..	..	..	..	..
43	5	1281	"	100/-	0/-	100/-	..	..	3/-	1/-	7/-	"	"	"	..	2	Brahman,	..	4	..	..	..	..	..	..
44	7	1281	"	330/-	8/-	338/-	..	..	3/-	1/-	4/-	"	"	"	..	7	Kachi,	..	3	..	..	..	..	..	..
45	7	1281	"	300/-	0/-	300/-	..	..	3/-	1/-	7/-	"	"	"	..	1	"	..	3	..	..	..	..	..	..
46	7	1281	"	300/-	0/-	300/-	..	..	3/-	1/-	7/-	"	"	"	..	1	"	..	3	..	..	..	..	..	..
47	8	1281	"	700/-	8/-	708/-	..	..	8/-	1/-	4/-	"	"	"	..	1	"	..	3	..	..	..	..	..	..
48	..	..	Kacha,	110/-	1/-	111/-	..	..	9/-	..	..	"	"	"	..	1	Ahli,	..	4	..	..	..	..	..	..
49	..	..	Masonry,	150/-	0/-	150/-	..	..	3/-	1/-	7/-	"	"	"	..	1	Musolman,	..	4	..	..	..	..	..	..
50	..	..	"	250/-	3/-	253/-	..	..	..	..	..	"	"	"	..	1	Kachi,	..	3	..	..	..	..	..	..
51	..	..	"	300/-	0/-	300/-	..	..	..	..	..	"	"	"	..	12	"	..	4	..	..	..	..	..	..
52	..	..	"	300/-	0/-	300/-	..	..	..	..	..	"	"	"	..	6	"	..	4	..	..	..	..	..	..
53	..	..	"	300/-	0/-	300/-	..	..	..	..	..	"	"	"	..	1	"	..	3	..	..	..	..	..	..
54	..	..	"	250/-	3/-	253/-	..	..	..	..	..	"	"	"	..	21	"	..	1	..	..	..	..	..	..
55	..	..	"	300/-	0/-	300/-	..	..	..	..	..	"	"	"	..	9	"	..	4	..	..	..	..	..	..
56	..	..	"	300/-	0/-	300/-	..	..	..	..	..	"	"	"	..	8	"	..	4	..	..	..	..	..	..
57	..	..	"	250/-	3/-	253/-	..	..	..	..	..	"	"	"	..	22	"	..	3	..	..	..	..	..	..
58	9	1281	"	400/-	0/-	400/-	..	..	3/-	1/-	7/-	"	"	"	..	1	"	..	4	..	..	..	..	..	..
59	10	..	"	500/-	3/-	503/-	..	..	2/-	1/-	8/-	"	"	"	..	1	"	..	3	..	..	..	..	..	..
60	..	..	"	500/-	0/-	500/-	..	..	2/-	1/-	5/-	"	"	"	..	1	Lochi,	..	4	..	..	..	..	..	..
61	11	..	"	300/-	3/-	303/-	..	..	2/-	1/-	3/-	"	"	"	..	3	Brahman,	..	3	..	..	..	..	..	..
62	0	182	"	300/-	0/-	300/-	..	..	9/-	1/-	11/-	Clay,	"	"	..	3	Kurni,	..	3	..	..	..	..	..	..
63	0	182	"	..	..	..	..	..	10/-	1/-	21/-	"	"	"	..	1	"	..	1	..	..	..	..	..	..
64	..	..	Kacha unlined,	175	4/-	575	..	..	10/-	1/-	21/-	"	"	"	..	2	Chamat,	..	3	..	..	..	..	..	..
65	..	..	"	..	..	..	..	..	10/-	7/-	17/-	"	"	"	..	2	"	..	12	..	..	..	..	..	..
66	10	182	"	..	..	..	..	..	10/-	1/-	11/-	"	"	"	..	3	Thakur,	..	2	..	..	..	..	..	..
67	10	182	"	..	..	..	..	..	10/-	1/-	11/-	"	"	"	..	2	Kachi,	..	2	..	..	..	..	..	..
68	10	182	"	..	..	..	..	..	10/-	1/-	11/-	"	"	"	..	0	Chamat,	..	2	..	..	..	..	..	..
69	10	182	"	..	..	..	..	..	10/-	1/-	11/-	"	"	"	..	0	Thakur,	..	3	..	..	..	..	..	..
70	10	182	"	..	..	..	..	..	10/-	1/-	11/-	"	"	"	..	0	Chamat,	..	3	..	..	..	..	..	..
71	10	182	"	..	..	..	..	..	10/-	1/-	11/-	"	"	"	..	0	Thakur,	..	3	..	..	..	..	..	..
72	10	182	"	..	..	..	..	..	10/-	1/-	11/-	"	"	"	..	0	Chamat,	..	3	..	..	..	..	..	..

TABLE A.—*Observation and Experiment—(Continued)*

## EXPERIMENTAL

[illegible]



TABLE A—Observation and Experiment—(Continued)

## EXPERIMENTAL

Work													Cost.				Remarks.							
Cable feet lifted				H. P.		Area irrigated				Depth		Days to an acre			Annual			Per Acre						
Duration of work minutes	No. of lifts	Per pair of cattle per hour	Per lift, per hour	Total per well.	Per bullock.	Total per well	Length of watercourse.	Crop	Watering	Interval.	Area in square feet.	On area.	Of damp	Per pair of cattle.	Per lift.	Per well.		Duty per pair	Interest at 5 p c	Repairs, &c	Total	Per acre irrigated.	Falling	Total
36	..	..	..	..	..	..	..	Opium, "	6	..	9,117	..	..	50	50	50	..	126	40	100	50	150	206	Opium
37	..	..	..	..	..	..	..	Sugar, "	..	..	4,611	..	..	91	91	94	..	126	40	106	60	188	112	Sugarcane
38	..	..	..	..	..	..	..	{ Tobacco, }	..	..	12,753	..	..	31	31	34	..	77	40	117	22	106	128	Tobacco
39	..	..	..	..	..	..	..	{ Opium, }	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Opium
40	..	..	..	..	..	..	500	Opium, "	..	..	3,610	..	..	120	120	120	..	101	10	111	..	..	..	Opium
41	..	..	..	..	..	..	300	Barley, "	1	..	5,372	..	..	160	160	80	..	78	70	118	..	..	..	Opium
42	..	..	..	..	..	..	200	" "	1	..	..	..	..	30	30	15	..	78	70	118	..	..	..	Opium
43	..	..	..	..	..	..	150	" "	1	..	6,787	..	..	128	128	64	..	53	70	123	..	..	..	Opium
44	..	..	..	..	..	..	50	Tobacco, "	2	..	6,303	..	..	82	82	273	..	280	110	390	..	..	..	Opium
45	..	..	..	..	..	..	..	" "	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Opium	
46	..	..	..	..	..	..	255	" "	2	..	6,500	171	..	66	66	66	..	115	40	155	..	..	..	Opium
47	440	424	167	157	1,145	1,882	828	" "	2	..	3,610	..	..	120	120	60	..	7	150	157	..	..	..	Opium
48	..	..	..	..	..	..	200	Sugar, "	2	..	6,352	..	..	272	136	68	..	78	70	118	..	..	..	Opium
49	..	..	..	..	..	..	..	Tobacco, "	2	..	..	..	..	1117	1117	180	..	560	230	780	..	..	..	Opium
50	..	..	..	..	..	..	..	{ Opium, }	..	..	..	..	..	1117	1117	180	..	560	230	780	..	..	..	Opium
51	..	..	..	..	..	..	..	{ Tobacco, }	..	..	..	..	..	1117	1117	180	..	560	230	780	..	..	..	Opium
52	..	..	..	..	..	..	..	{ Vegetables, }	..	..	..	..	..	1117	1117	180	..	560	230	780	..	..	..	Opium
53	..	..	..	..	..	..	..	" "	..	..	23,100	..	..	1117	1117	180	..	560	230	780	..	..	..	Opium
54	..	..	..	..	..	..	..	" "	..	..	..	..	..	1117	1117	180	..	560	230	780	..	..	..	Opium
55	..	..	..	..	..	..	..	" "	..	..	28,000	..	..	108	108	1.5	..	580	250	830	..	..	..	Opium
56	..	..	..	..	..	..	..	" "	..	..	..	..	..	108	108	1.5	..	580	250	830	..	..	..	Opium
57	..	..	..	..	..	..	..	" "	..	..	..	..	..	108	108	1.5	..	580	250	830	..	..	..	Opium
58	..	..	..	..	..	..	100	{ Opium, }	2	..	2,969	..	..	30	30	15	..	203	70	273	..	..	..	Opium
59	3000	118	40	40	471	1,105	870	Opium, "	2	..	160	21	..	136	136	136	..	265	30	295	..	..	..	Opium
60	..	..	..	..	..	..	..	" "	2	..	1,500	..	..	87	87	43	..	303	30	353	..	..	..	Opium
61	..	..	..	..	..	..	..	" "	2	..	3,206	..	..	132	132	132	..	151	30	181	..	..	..	Opium
62	..	..	..	..	..	..	..	" "	2	..	..	..	..	132	132	132	..	151	30	181	..	..	..	Opium
63	500	370	720	720	1,184	1,100	580	Barley, "	1	..	7,200	161	..	12	12	6	..	157	110	263	..	..	..	Opium
64	..	..	..	..	..	..	..	" "	..	..	..	..	..	12	12	6	..	157	110	263	..	..	..	Opium
65	485	203	753	753	608	1,250	606	" "	1	..	5,100	119	..	84	84	84	..	93	210	215	..	..	..	Opium
66	..	..	..	..	..	..	..	" "	1	..	22,310	..	..	133	133	133	..	177	70	787	..	..	..	Opium
67	..	..	..	..	..	..	..	Whent, "	1	..	..	..	..	133	133	133	..	177	70	787	..	..	..	Opium
68	510	572	754	858	1,044	854	401	" "	1	..	9,802	156	..	107	80	44	..	01	210	211	..	..	..	Opium
69	..	..	..	..	..	..	..	" "	1	..	..	..	..	107	80	44	..	01	210	211	..	..	..	Opium
70	540	286	114	114	1026	1500	815	" "	1	..	4,514	227	..	97	97	97	..	03	110	113	..	..	..	Opium

TABLE A.—Observation and Experiment—(Continued)

## STATISTICAL

Serial Number	Locality		Area in Acres				Cultivated Area				Percentage of Total Cultivated Area										Irrigation Wells				Lifts		Usual labor for lifting buckets.		Average area per lift, in acres.		Remarks					
			Actual area in acres.		Percentage uncultivated		Percentage of actual area cultivated		Double cropped area in acres		Total area actually cultivated in the year		Wet		Dry		Wet		Wet		Wet		Wet		Wet		Wet		Wet							
			7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35					
Perganna	Village	Year	Actual area in acres.		Percentage uncultivated		Percentage of actual area cultivated		Double cropped area in acres		Total area actually cultivated in the year		Wet		Dry		Wet		Wet		Wet		Wet		Wet		Wet		Wet		Total	Remarks				
			7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35					
LAKSHADWEEP																																				
74	Chubriman, ..	1879-80	3457	134	196	670	4082	2739	408	592	18	18	..	496	444	390	..	160	536	..	..	..	..	57	57	57	57	57	57	57	57	57	57			
75	" ..	80-81	3457	134	196	670	4721	2786	475	525	18	18	..	444	462	354	..	81	538	..	..	..	..	57	57	57	57	57	57	57	57	57	57			
76	Annapur, ..	79-80	9222	173	65	702	1989	7049	21	999	09	09	..	09	09	21	..	970	991	..	..	..	16	16	16	16	16	16	16	16	16	16	16			
77	" ..	80-81	9222	173	65	702	1989	7049	21	999	09	09	..	09	09	21	..	970	991	..	..	..	16	16	16	16	16	16	16	16	16	16	16			
78	Ganakhabad, ..	79-80	222	1144	184	7011	1275	283	13	56	1947	209	..	1033	1301	5837	..	057	233	5699	..	..	61	61	61	61	61	61	61	61	61	61	61	61		
79	" ..	80-81	222	1166	1489	7412	15294	31748	7790	2210	2055	..	..	2125	4780	5135	..	..	056	5250	..	..	61	61	61	61	61	61	61	61	61	61	61	61		
80	" ..	79-80	12914	145	165	390	4589	9617	789	211	24	24	..	100	124	765	..	111	875	..	..	12	12	39	39	39	39	39	39	39	39	39	39	39		
81	Tajpur, ..	80-81	12914	145	165	390	5123	10146	880	114	335	..	..	106	441	551	..	..	08	559	..	..	39	39	39	39	39	39	39	39	39	39	39	39		
82	" ..	79-80	23709	1035	2611	6254	704	1577	991	8009	467	..	..	4846	4919	888	..	86	4165	5087	..	..	2 p-3	1 p-112	119	128	..	128	..	109	117	117	117			
83	" ..	80-81	23709	1035	1685	7280	..	1726	4065	5965	13	77	18	4980	4497	863	2776	298	1576	5509	..	..	1 p-89	94	101	101	101	101	101	101	101	101	101	101	101	
84	" ..	79-80	26623	2356	2483	5161	204	1578	4360	5750	168	081	008	4903	5162	2248	276	1466	848	4838	..	..	19	142	125	125	125	125	125	125	125	125	125	125		
85	" ..	80-81	26623	2306	2522	5073	2404	15908	5907	1693	1186	214	052	4221	5676	2175	374	1306	469	4821	..	..	10	196	128	128	128	128	128	128	128	128	128	128	128	
86	" ..	79-80	25174	574	340	9086	225	231	2656	7344	138	..	..	5698	5776	2518	..	1706	4224	..	..	1	3	9	9	9	9	9	9	9	9	9	9	9	9	
87	" ..	80-81	25174	70	603	8098	124	231	280	714	46	..	..	628	674	240	..	86	326	..	..	..	..	10	10	10	10	10	10	10	10	10	10	10	10	
88	Jagpur, ..	79-80	25174	574	340	9086	225	231	2656	7344	138	..	..	5698	5776	2518	..	1706	4224	..	..	1	3	9	9	9	9	9	9	9	9	9	9	9	9	
89	" ..	80-81	25174	70	603	8098	124	231	280	714	46	..	..	628	674	240	..	86	326	..	..	..	..	10	10	10	10	10	10	10	10	10	10	10	10	10
90	" ..	79-80	25174	574	340	9086	225	231	2656	7344	138	..	..	5698	5776	2518	..	1706	4224	..	..	1	3	9	9	9	9	9	9	9	9	9	9	9	9	9
91	" ..	80-81	25174	70	603	8098	124	231	280	714	46	..	..	628	674	240	..	86	326	..	..	..	..	10	10	10	10	10	10	10	10	10	10	10	10	10
92	" ..	79-80	25174	574	340	9086	225	231	2656	7344	138	..	..	5698	5776	2518	..	1706	4224	..	..	1	3	9	9	9	9	9	9	9	9	9	9	9	9	9
93	" ..	80-81	25174	70	603	8098	124	231	280	714	46	..	..	628	674	240	..	86	326	..	..	..	..	10	10	10	10	10	10	10	10	10	10	10	10	10
94	" ..	79-80	25174	574	340	9086	225	231	2656	7344	138	..	..	5698	5776	2518	..	1706	4224	..	..	1	3	9	9	9	9	9	9	9	9	9	9	9	9	9
95	" ..	80-81	25174	70	603	8098	124	231	280	714	46	..	..	628	674	240	..	86	326	..	..	..	..	10	10	10	10	10	10	10	10	10	10	10	10	10
96	" ..	79-80	25174	574	340	9086	225	231	2656	7344	138	..	..	5698	5776	2518	..	1706	4224	..	..	1	3	9	9	9	9	9	9	9	9	9	9	9	9	9
97	" ..	80-81	25174	70	603	8098	124	231	280	714	46	..	..	628	674	240	..	86	326	..	..	..	..	10	10	10	10	10	10	10	10	10	10	10	10	10
98	" ..	79-80	25174	574	340	9086	225	231	2656	7344	138	..	..	5698	5776	2518	..	1706	4224	..	..	1	3	9	9	9	9	9	9	9	9	9	9	9	9	9
99	" ..	80-81	25174	70	603	8098	124	231	280	714	46	..	..	628	674	240	..	86	326	..	..	..	..	10	10	10	10	10	10	10	10	10	10	10	10	10
100	" ..	79-80	25174	574	340	9086	225	231	2656	7344	138	..	..	5698	5776	2518	..	1706	4224	..	..	1	3	9	9	9	9	9	9	9	9	9	9	9	9	9
101	" ..	80-81	25174	70	603	8098	124	231	280	714	46	..	..	628	674	240	..	86	326	..	..	..	..	10	10	10	10	10	10	10	10	10	10	10	10	10
102	" ..	79-80	25174	574	340	9086	225	231	2656	7344	138	..	..	5698	5776	2518	..	1706	4224	..	..	1	3	9	9	9	9	9	9	9	9	9	9	9	9	9
103	" ..	80-81	25174	70	603	8098	124	231	280	714	46	..	..	628	674	240	..	86	326	..	..	..	..	10	10	10	10	10	10	10	10	10	10	10	10	10
104	" ..	79-80	25174	574	340	9086	225	231	2656	7344	138	..	..	5698	5776	2518	..	1706	4224	..	..	1	3	9	9	9	9	9	9	9	9	9	9	9	9	9
105	" ..	80-81	25174	70	603	8098	124	231	280	714	46	..	..	628	674	240	..	86	326	..	..	..	..	10	10	10	10	10	10	10	10	10	10	10	10	10
106	" ..	79-80	25174	574	340	9086	225	231	2656	7344	138	..	..	5698	5776	2518	..	1706	4224	..	..	1	3	9	9	9	9	9	9	9	9	9	9	9	9	9
107	" ..	80-81	25174	70	603	8098	124	231	280	714	46	..	..	628	674	240	..	86	326	..	..	..	..	10	10	10	10	10	10	10	10	10	10	10	10	10
108	" ..	79-80	25174	574	340	9086	225	231	2656	7344	138	..	..	5698	5776	2518	..	1706	4224	..	..	1	3	9	9	9	9	9	9	9	9	9	9	9	9	9
109	" ..	80-81	25174	70	603	8098	124	231	280	714	46	..	..	628	674	240	..	86	326	..	..	..	..	10	10	10	10	10	10	10	10	10	10	10	10	10
110	" ..	79-80	25174	574	340	9086	225	231	2656	7344	138	..	..	5698	5776	2518	..	1706	4224	..	..	1	3	9	9	9	9	9	9	9	9	9	9	9	9	9
111	" ..	80-81	25174	70	603	8098	124	231	280	714	46	..	..	628	674	240	..	86	326	..	..	..	..	10	10	10										

TABLE A — Observation and Experiment—(Continued)

## DISCHURIVE

Date			Class	Cost						Supply	Quality	Substratum	Cultivators on well		Labor and cost per day in annas									
Serial Number	Day	Month		Year	Construction.	ittings.	Total.	Renewal.	Lifts.				Yearly repairs.	Total.	Number	Caste	Men, home.	Do, hired	Rate, per day	Cattle.	Cost for men	Do for cattle.	Total cost, per day	
87	38	30	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	
74	11	182	160	Kacha lined, ..	3 75	8/	0 75	..	7/	1/	8/	..	..	..	1	Kachi, ..	2	1	..	2 5	3	2 5	3	-15/6
78	11	182	165	" "	3 75	8/	0 75	..	7/	1/	8/	..	..	..	3	" "	2	1	..	2 5	8	2 5	8	-15/6
80	11	182	81	" "	5/	8/	8/	..	7/-	1/-	8/	..	..	..	1	" "	3	..	..	2	3	2	3	-15/6
84	11	182	177	" "	3 75	9/	0 75	..	7/	1/	8/	..	..	..	1	" "	3	..	..	2	3	2	3	-15/6
86	12	482	..	" "	1 5	1/	2 5	1/	..	..	1 5	..	..	Sand, ..	1	" "	1	..	..	..	1	..	..	-11/-
87	12	482	..	" "	1 5	1/	2 5	1/	..	..	1 5	..	..	" Clay, ..	1	" "	2	..	..	..	3 1/2	..	..	-11/-
88	12	482	..	Kacha unlined, ..	9/	0/	6/	..	10/	1/	11/	Spring, ..	Sweet, ..	..	1	" "	1	1	1 1/2	1 1/2	2	3 1/2	..	-10/6
90	12	482	23	" "	3/	0/	0/	..	9/	1/	10/	" "	" "	..	1	" "	1	1	1 1/2	1 1/2	3	3	..	-10/6
92	15	482	145	Kacha lined, ..	5/	3/	8/	1 5	8/	1/	10 5	" "	" "	..	1	" "	3	..	..	2	3	2	3	-15/-
94	15	482	185	" "	5/	3/	8/	1 5	8/	1/	10 5	" "	" "	..	1	Lodha, ..	1	2	2 1/2	4	3	4	3	-17/-
96	10	182	1,121	Masonry, ..	2 50/	6/	2 50/	..	5/	1/	11/	Percolation, ..	" "	Sand, ..	..	" "	1	3	3 75	3 0	6	3	6	-10/6
99	12	182	281	" "	2 50/	3/	2 50/-	..	5/	1/	6/	Spring, ..	" "	Clay, ..	..	Brahmin, ..	3	..	..	2	3	2	3	-15/-
100	15	182	2,067	" "	4 00/	12/	4 12/	..	6/	1/	25/	" "	..	" "	6	Lodha, ..	7	1	1 5	8	7 5	12	13/6	
100	15	182	2,060	" "	4 00/	12/	4 12/	..	5/	1/	21/	" "	..	" "	4	Lodha, ..	7	..	..	8	0	12	13/-	
110	10	182	81	" "	2 50/	13/	2 83/	..	4/	1/	17/	" "	..	" "	5	Brahmin, ..	..	..	..	..	0	24	1/14/-	
															2	Chamar, ..	7	..	..	..	..	..	..	
															2	Lodha, ..	..	..	..	..	..	..	..	

TABLE A — Observation and Experiment—(Continued)

## EXPERIMENTAL.

( III )

AREA IRRIGATED TO DATE																																	
COMMAND																																	
Kharif 1881-82													Rabi 1881-82																				
Serial Number	Class	Pairs of cattle to each lift	Lift			Depth to Wells			Soil	Kharif 1881-82						Rabi 1881-82						Kharif 1881-82						Rabi 1881-82					
			Number	Content in cubic feet	Morning	Evening	Mean	69		Crop	Waterings required	Area	Total area reduced to one watering	No of days to area.	Crop	Waterings required	Area	Total area reduced to one watering	No of days to area.	Crop	Waterings given	Area	Working days to	Per lift	Per pair	Crop	Waterings given	Area	Working days to	Per lift	Per pair		
74	Lagor,	1	1	3 7125	31	36	35	Dumat,	..	..	..	..	Barley, Guja, Wheat, Opium,	2 3 4 12	1 26 0 66 0 37	12 18	92	..	..	..	..	..	..	..	Barley, Guja, Wheat, Opium,	2 2 3 17	1 26 0 66 0 37	160 100 80 60	0 157 0 170 0 169 0 185	..	..		
76	"	1	1	3 375	32	34	33	"	..	..	..	..	Guja, Wheat, Barley,	3 3 2	1 60 0 943 0 671	9 16	66	..	..	..	..	..	..	Guja, Wheat, Barley,	1 1 1	1 60 0 943 0 671	150 130 80	0 180 0 128 0 118	..	..			
80	"	1	1	..	30	35	32 5	"	..	..	..	..	Guja, Wheat, Barley,	4 2 4	1 09 0 943 0 671	12 23	67	..	..	..	..	..	..	Guja, Wheat, Barley,	1 2 2	1 09 0 943 0 671	140 140 114	0 79 0 179 0 114	..	..			
84	"	1	1	..	35	..	..	"	..	..	..	..	Opium, Wheat, Garden,	12 12 12	0 800 0 30 0 6	7 2	40	..	..	..	..	..	..	Opium, Wheat, Garden,	2 2 2	0 800 0 30 0 6	30 10 3	0 200 0 180 0 200	..	..			
86	Dhenkli,	..	1	0 4	15	15	15	Matyar,	..	..	..	..	Potatoes, Tobacco,	12 12	1 73 1 73	20 76	10 9	..	..	..	..	..	..	Potatoes, Tobacco,	12 12	1 73 1 73	66 66	0 28 0 28	..	..			
87	"	..	1	0 1	16	16	16	"	..	..	..	..	Potatoes, Tobacco,	12 12	1 73 1 73	20 76	10 9	..	..	..	..	..	..	Potatoes, Tobacco,	12 12	1 73 1 73	66 66	0 28 0 28	..	..			
88	Lagor,	1	1	5 74	56	56	56	Dumat,	Indian corn, Jowar,	2 2	1 5 0 23	3 46	18	..	..	..	20 76	10 9	..	..	..	..	..	..	Indian corn, Jowar,	2 2	1 5 0 23	66 66	0 32 0 32	..	..		
90	"	..	1	1 480	57	59	58	"	..	..	..	..	Potatoes, Tobacco,	10 10	1 63 1 63	16 30	57	..	..	..	..	..	..	Potatoes, Tobacco,	10 10	1 63 1 63	50 50	0 32 0 32	..	..			
92	"	1	1	3 32	35	37	36	"	..	..	..	..	Potatoes, Tobacco,	4 4	1 29 1 29	5 16	26	..	..	..	..	..	..	Potatoes, Tobacco,	10 10	1 29 1 29	50 50	0 26 0 26	..	..			
94	"	1	1	1 40	34	37	35 5	"	..	..	..	..	Potatoes, Tobacco,	0 0	1 17 1 17	11 70	58	..	..	..	..	..	..	Potatoes, Tobacco,	10 10	1 17 1 17	10 10	0 19 0 19	..	..			
96	"	1	2	2 8125	14	24	19	Sandy,	..	..	..	..	Barley, Guja, Wheat,	2 2 3	1 23 3 88 1 40	12 92	56 7	..	..	..	..	..	..	Barley, Guja, Wheat,	1 1 1	1 23 3 88 1 40	31 31 31	0 105 0 105 0 105	..	..			
98	"	1	1	..	15	..	..	Dumat,	..	..	..	..	Wheat, Guja, Barley & Gram,	3 3 3	1 20 5 65 3 86	9 60	21 6	..	..	..	..	..	..	Wheat, Guja, Barley & Gram,	1 1 1	1 20 5 65 3 86	6 6 6	0 20 0 101 0 133	..	..			
100	"	1	4	3 1725	16	27	21 5	"	..	..	..	..	Wheat, Garden, Opium,	3 10 10	3 86 0 40 0 40	4 37	12 4	..	..	..	..	..	..	Wheat, Garden, Opium,	1 7 4	3 86 0 40 0 40	18 1 0 200 0 200	0 133 0 100 0 148	..	..			
106	"	1	4	2 925	13	17	15	"	..	..	..	..	Barley, Guja, Wheat, Garden,	2 9 3	2 37 2 77 3 24 6	40 98	53	..	..	..	..	..	..	Barley, Guja, Wheat, Garden,	1 1 1	2 37 2 77 3 24 6	12 8 26 25	0 166 0 117 0 126 0 103	..	..			
110	"	2	4	2 51	18	23	20 5	"	..	..	..	..	Barley, Wheat, Garden,	8 2 2	2 46 1 94 3 90	50 7	95	..	..	..	..	..	..	Barley, Wheat, Garden,	7 2 3	2 46 1 94 3 90	26 23 51	0 183 0 131 0 145	0 188 0 095 0 072	0 074			



TABLE A.—*Observation and Experiment—(Continued).*

Locality		Year	Area in Acres			Cultivated Area			Percentage of Total Cultivated Area										Irrigation Wells				Lifts			Average area per lift, in acres			Remarks						
			Actual area in acres.	Percentage uncultivated		Double cropped area in acres	Total area actually cultivated in the year	Wet.	Dry.	Kharif				Rabi.				Tame masonry.	Dry bricks.	Kacha.	Total.	Leather bucket.	Kharren pots.	Total.	Usual labor for lifting buckets.	Kharif.	Rabi.	Total.							
				Waste.	Culturable.					Wells.	Canals.	Other sources.	Wet.	Dry.	Total.	Wells.	Canals.													Other sources.	Wet.	Dry.	Total.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
1113	Malnuri, "	Hasanpur, "	1870	108 57	19 2	7 2	57 6	7 06	97 2	15 3	51 8	5 6	..	..	31 0	90 0	39 0	..	..	28 8	63 1	1 2	3	9	..	..	1 p 1	3	9	..	..	0 60	4 28	4 88	{ All these Wells have splendid springs.
1116	" "	" "	80 81	108 37	39 1	0 1	51 5	4 63	96 37	58 0	11 1	9 8	..	..	38 0	17 8	48 8	..	..	3 4	52 3	4 p 3	3	9	..	..	1 p 1	3	9	..	1 05	5 22	6 27	" "	
1117	" "	Sansarpur, "	79 80	114 21	30 63	10 08	53 39	5 41	733 50	41 5	58 5	0 4	..	..	17 2	53 6	35 1	..	..	11 3	40 4	25	7	51	7 58	..	7	32	51	7 58	0 81	4 41	5 25	" "	
1118	" "	" "	80 81	111 21	30 51	11 73	57 76	61 66	723 60	54 5	15 5	15 1	..	..	30 10	51 5	39 1	..	..	0 1	15 5	27	15	42	45	15 60	..	15	42	45	15 60	1 85	4 72	6 57	
1231	Chitor, "	Chitor, "	79 80	910 8	38 43	4 03	56 64	292 2	1308 8	57 83	42 18	7 95	5 26	0 16	20 81	43 21	15 01	26 97	1 57	12 34	50 79	2 p 4	61	81	85	..	85	61	81	85	..	1 28	2 56	3 84	{ Village close to Ganges Canal. Note kacha wells
1232	" "	" "	80 81	1900 8	11 67	5 87	53 46	271 97	1272 17	72 10	27 90	10 8	17 70	1 01	22 62	52 22	20 40	21 76	0 84	5 28	47 78	1 p 16 2 p 4 1 p 18	66	86	90	..	90	66	86	90	..	1 52	2 68	4 40	
1409	Shikohabad, Ist.	Shikohabad, "	79 80	127 51	14 60	17 95	67 15	96 5	382 16	23 35	76 65	2 88	..	..	55 30	58 18	20 04	..	0 43	21 35	41 82	..	25	25	27	..	27	25	27	..	0 40	2 83	3 38	{ First Year Canal Note effect.	
1410	" "	" "	80 81	422 21	15 11	6 21	78 62	29 0	361 94	35 79	61 21	7 22	..	..	57 06	61 61	17 26	10 95	..	7 15	35 86	..	28	28	28	..	28	28	28	..	0 02	2 22	3 14		
1411	" "	Shikohabad, "	79 80	781 29	30 0	7 3	62 8	150 19	612 43	39 6	66 1	1 3	..	..	60 2	61 1	29 4	..	..	0 2	35 6	18	58	76	92	..	92	58	76	92	..	0 30	2 04	2 34	
1412	" "	" "	80 81	781 29	29 8	9 0	61 2	108 14	532 23	52 5	17 5	14 05	..	..	13 1	58 1	33 0	0 8	4 0	4 1	11 9	19	67	86	93	..	93	67	86	93	..	0 35	2 15	3 10	
1413	" "	2nd, "	79 80	798 67	12 9	28 8	58 7	0 8	233 1	12 5	57 5	0 4	..	..	18 9	19 3	12 1	..	..	8 6	50 7	2 p 1	25	27	28	..	28	25	27	28	..	0 03	2 15	2 48	
1414	" "	" "	80 81	398 67	13 5	29 5	57 0	32 1	256 33	50 9	19 1	1 0	..	..	46 5	47 5	7 2	42 7	..	2 6	52 5	2 p 1 1 p 1 2 p 1	26	28	29	..	29	26	28	29	..	0 10	0 45	0 55	

TABLE A.—Observation and Experiment—(Continued)

Desamiriyin																								
Date			Class	Cost.					Supply	Quality	Substratum	Cultivators on well		Labor and cost per day in annas.										
Serial Number	Day	Month		Year	Construction.	Bitings.	Total	Renewal				Tails	Yearly repairs	Total	Number	Caste.	Men, home.	Do hired	Rate, per day	Cattle.	Cost for men	Do. for cattle.	Total cost, per day	
37	08	39	40	43								50	51	52	53	54	55	56	57	58	59	60	61	
118	16	182	100	Masonry,	250/-	10/-	200/-	..	5/-	1/-	16/-	Spring, ..	Sweet, ..	Clay,	{ 4	Brahmin, Chamar, Kachi, Herdaman,	{ 0	1	1.5	6	6.5	9	-15/6	
117	17	182	510	"	250/-	12/-	262/-	..	0/-	1/-	25/-	"	"	"	{ 12	Brahmin, Ahit,	{ 5	4	1.5	9	10	13.5	17/6	
120	18	182	511	"	150/-	6/-	156/-	..	5/-	3/-	13/-	"	"	"	..	Brahmin,	..	3	2	1.5	4	5	0	-11/-
123	18	182	701	"	200/-	6/-	200/-	..	5/-	3/-	13/-	"	"	"	..	Brahmin,	..	4	1	1.5	6	4.5	9	-13/6
128	18	182	1,016	"	250/-	12/-	262/-	..	5/-	1/-	21/-	"	"	"	{ 6	Brahmin, Chamar, Kachi, Lothia, Kachi,	{ 2	5	1.5	6	8.5	9	1/1/6	
131	19	182	2,000	"	100/-	3/-	103/-	..	7/-	1/-	8/-	Percolation, ..	"	Sand,	{ 3	Lothia, Kachi,	{ 3	0	..	2	2	3	-5/-	
133	19	182	2,070	"	100/-	3/-	103/-	..	0/-	1/-	7/-	"	"	"	{ 2	Chamar, Kachi, Lothia,	{ 2	1	1.5	2	2.5	3	-5/6	
136	21	182	183	Kucha lined,	..	2/-	6/-	4/-	7/-	..	11/-	"	"	Clay,	..	Lothia, Lothia,	..	2	1	1.5	2	2.5	3	-5/6
138	21	182	125	"	4/-	2/-	6/-	4/-	7/-	..	11/-	"	"	"	..	Lothia,	..	1	2	1.5	2	4	3	-7/-
140	21	182	127	"	4/-	2/-	6/-	4/-	7/-	..	11/-	"	"	"	..	Lothia,	..	2	1	1.5	2	2.5	3	-5/6
141	22	182	511	"	7/-	2/-	9/-	4/-	7/-	..	11/-	Spring, ..	"	"	{ 1	Lothia, Ahit,	{ 1	2	1.5	2	3	3	0	-10/-
143	22	182	683	Masonry,	150/-	6/-	156/-	..	7/-	1/-	15/-	"	"	"	..	Lothia,	..	1	2	1.5	4	3	0	-10/-
147	23	182	261	Kucha lined,	..	3/-	10/-	3/-	0/-	..	9/-	Percolation, ..	"	Sand,	..	Ahit,	..	1	..	..	2	3	0	-5/-

TABLE A — Observation and Experiment—(Continued)

EXPERIMENTAL.																								
AREA IRRIGATED TO DATE.																								
COMMAND																								
Kharif 1881-82										Rabi 1881-82														
Serial Number	Class	Pairs of cattle to each lift	Lift			Soul	Kharif 1881-82				Rabi 1881-82				Kharif 1881-82				Rabi 1881-82					
			Number	Content in cubic feet	Morning	Evening	Mean.	Crop	Waterings required.	Area	Total area reduced to one watering	No of days to area	Crop.	Waterings required	Area	Total area reduced to one watering	No of days to area.	Crop	Waterings given.	Area	Working days to date.	Per lift.	Per pair	
62		63	64	65	66	67	68		70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85
113	Lagot,	..	3	27	16 6	18	17 3	Dumat,	..	..	..	..	..	Gujar,	8	13 0	52 12	151	..	..	..	..	..	..
117	"	..	4	3 15	18	20	19	"	..	..	..	..	..	Barley,	2	3 28	50 08	100	..	2	28	..	..	..
120	"	..	2	2 05	17	20 5	18 75	"	..	4	3 17	12 68	38	Gujar,	3	1 43	15 46	46	..	15	28	12	0 175	0 175
129	"	..	2	3 015	16	26	21	"	..	4	1 8	7 2	..	Gujar,	3	1 97	39 80	86	..	2	18	14	0 130	0 03
128	" (4 ft.)	1	3	3 03 1	16	18	17	"	..	..	..	..	..	Barley,	2	2 77	45 74	102	..	..	..	..	..	..
131	"	..	1	4 05	10 4	17	13 7	Matyar,	..	..	..	..	..	Gujar,	3	1 11	24 8	131	..	..	..	..	..	..
133	"	1	1	3 19	9	13	10 5	Dumat,	..	..	..	..	..	Barley,	2	1 50	13 18	76	..	..	..	..	..	..
136	"	..	1	4 05	13	18	15	Sandy,	..	..	..	..	..	Opium,	3	0 46	11 18	89	..	..	..	..	..	..
139	"	..	1	4 106	13	21	17	Dumat,	..	..	..	..	..	Barley,	2	1 12	17 43	68	..	..	..	..	..	..
140	"	..	1	1 16	13	23	18	Sandy,	..	..	..	..	..	Garden,	3	0 15	13 2	42	..	..	..	..	..	..
141	"	1	1	4 05	11 5	19	16 75	"	..	..	..	..	..	Wheat,	3	4 4	12 3	78	..	..	..	..	..	..
143	"	..	2	4 725	17	21 5	20 75	"	..	..	..	..	..	Barley,	2	1 9	33	125	..	..	..	..	..	..
147	"	..	1	3 4875	21 5	29	25 25	"	..	..	..	..	..	Carrots,	3	0 7	10 52	84	..	..	..	..	..	..
														Gujar,	3	1 74	10 52	84	..	..	..	..	..	..
														Wheat,	4	1 14	10 52	84	..	..	..	..	..	..
														Wheat,	4	1 14	10 52	84	..	..	..	..	..	..
														Wheat,	4	1 14	10 52	84	..	..	..	..	..	..
														Wheat,	4	1 14	10 52	84	..	..	..	..	..	..
														Wheat,	4	1 14	10 52	84	..	..	..	..	..	..
														Wheat,	4	1 14	10 52	84	..	..	..	..	..	..
														Wheat,	4	1 14	10 52	84	..	..	..	..	..	..
														Wheat,	4	1 14	10 52	84	..	..	..	..	..	..
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TABLE A — Observation and Experiment—(Continued)

EXPERIMENTAL

Serial Number		WORK										Cost.						Remarks									
		Cubic feet lifted					H P		Area Irrigated			Days to an Acre			Annual				Per Acre								
		Duration of work minutes	No of lifts	Per pair of cattle per hour	Per lift, per hour	Total per well	Per bullock.	Total per well.	Length of watercourse.	Crop	Watering	Interval	Area in square feet.	On area	Of damp	Per pair of cattle.	Per lift.		Per well.	Duty per pair	Interest at 5 p c	Repairs, &c	Total	Per acre Irrigated	Lifting	Total	
113	540	1,303	129	129	3,518	605	880	1,280	880	Gujal,	2	45 days,	14,904	236	66	88	88	29	•	130	160	290	•	•	•	•	
117	600	2,111	147	166	6,650	771	463	1,710	463	Barley,	2	80 days,	22,000	37	75	90	80	20	•	131	250	381	•	•	•	•	
120	530	1,112	166	166	3,280	892	531	370	531	Barley,	•	2	45 days,	14,380	228	80	60	60	30	•	78	130	208	•	•	•	•
122	630	1,195	111	171	3,603	787	496	(870) (870) (550)	496	Carrots, Wheat,	5 2 2	• 30 days, •	3,332 5,180 6,000	274	75	65	43	218	•	103	130	233	•	•	•	•	
128	520	1,090	130	130	3,388	612	318	1,030	318	Wheat,	•	3	45 days,	19,434	174	76	672	672	224	•	131	210	341	•	•	•	•
131	550	620	271	274	2,511	1,200	660	370	660	Wheat,	2	60 days,	8,027	31	10	54	54	54	•	51	80	131	•	•	•	•	
133	530	468	181	181	1,698	556	295	680	295	Wheat,	•	2	30 days,	7,509	226	76	58	58	58	•	51	70	121	•	•	•	•
136	376	291	187	187	1,178	873	328	450	328	Wheat,	1	•	4,890	24	80	80	80	80	•	03	110	113	•	•	•	•	
138	522	510	255	255	2,317	1,380	720	370	720	Wheat,	2	37 days,	11,322	195	66	39	39	39	•	03	110	113	•	•	•	•	
140	530	465	222	222	1,031	1,302	600	310	600	Wheat,	•	2	45 days,	13,450	111	5	32	32	32	•	03	110	113	•	•	•	•
141	398	297	182	182	1,203	0,900	355	240	355	Wheat,	•	2	30 days	7,240	163	5	60	60	60	•	05	110	115	•	•	•	•
148	360	563	222	222	2,660	1,868	500	560	500	{ Wheat, Barley,	1	•	11,400	233	8	70	70	38	•	78	150	228	•	•	•	•	
147	440	308	140	140	1,071	1,107	487	180	487	Wheat,	•	2	30 days,	5,332	191	8	8	8	8	•	05	90	95	•	•	•	•

TABLE A — Observation and Experiment—(Continued)

## STATISTICAL.

Locality		Province		District		Village		Year		Area in Acres				Cultivated Area				Percentage of Total Cultivated Area.												Irrigation Wells.				Lifts				Average area per lift, in acres			Remarks																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
										Actual area in acres.	Waste	Percentage uncultivated	Percentage of actual area cultivated	Double cropped area in acres	Total area actually cultivated in the year.	Wet		Dry		Total		Wet		Dry		Total		Wells	Canals	Other sources.	Wells	Canals	Other sources.	Total	Dry bricks.	Kacha.	Leather bucket.	Earthen pots.	Total.	Usual labor for lifting in buckets.		Khamt.	Rabi.	Total.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
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155	Shikohabad, "	Mandpur, (contd.)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												

TABLE A.—*Observation and Experiment*—(Continued).

## DESCRIPTIVE

Date			Class	Cost					Supply	Quality	Substratum	Cultivators on well		Labor and cost per day in annas									
Serial Number	Month	Year		Construction.	Bitings	Total	Renewal	Tolls.				Yearly repairs.	Total	Number	Caste	Men, home.	Do hired	Rate, per day	Cattle.	Cost for men	Do for cattle	Total cost, per day	
37	38	40	42	48	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	
150	23	182	Masonry,	200/	3/-	208/	..	8/-	1/-	9/-	Spring,	Sweet,	Clay,	1	Ahur,	2	2	1 5	6	4	9	-13/-	
153	23	182	"	300/	6/-	306/	..	7/-	1/-	15/-	"	"	"	3	"	4	1	1 5	9	1 5	13 5	1/2/-	
155	24	182	Dry brck,	200/-	10/-	210/	..	6/-	1/-	25/-	"	"	"	1	"	3	4	1 5	8	8	12	1/4/-	
160	21	182	"	200/	15/-	215/-	..	5/-	1/-	31/-	"	"	"	{ 4 Kachi, Ahir, Brahman, Chamur, }		4	3	1 5	13	7 5	19 5	1/11/-	
166	25	182	Kacha lined with wood below,	30/	4/-	136/	..	6/-	1/-	30/-	"	"	Clay, 32',	11	Herdaman,	2	3	1 5	1	5 5	6	-11/6	
167	26	182		30/	4/-		30/	4/-	6/-		2/-	"		6	3	1 5	14	9 5	21	1/14/6			
.	.	.		30/	4/-		30/	4/-	6/-		2/-	"		6	3	1 5	14	9 5	21	1/14/6			
170	25	182	Masonry,	200/	6/-	206/	..	6/-	1/-	13/-	"	"	"	{ 2 Ahir, Thakur, Herdaman, }		2	2	1 5	4	1	6	-10/-	
173	23	182	Dry brck,	150/	12/-	162/	..	5/-	2/-	22/-	Percolation,	"	"	6	"	6	..	8	5	12	1/11/-		
178	27	182	Masonry,	150/	6/-	362/	..	5/-	2/-	17/-	Spring,	"	Clay, 45',	7	Ahur,	5	1	1 5	0	5 5	9	-14/6	
180	27	182	"	200/-	8/-		200/-	..	5/-	1/-	11/-	"	"	"	{ 1 Kachi, Ahir, }		2	2	1 5	1	4	6	-10/-
188	27	182	"	100/	6/-		106/	..	5/-	1/-	11/-	"	"	"	{ 1 Kachi, Ahir, Carpenter, }		2	1	1 5	1	2 5	6	-8/6

TABLE A — *Observation and Experiment—(Continued)*

EXPERIMENTAL														
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TABLE A.—Observation and Experiment—(Continued).

( 7 )

EXPERIMENTAL

Work																									Cost.					Remarks
Serial Number	Duration of work				Cubic feet lifted.				H. P.		Area irrigated.				Depth				Days to an acre				Annual			Per Acre.				
	minutes.	No. of lifts	Per pair of cattle per hour	Per lift, per hour.	Total per well	Per bullock.	Total per well	Length of watercourse.	Crop.	Watering	Interval	Area in square feet.	On area.	Of dump	Per pair of cattle.	Per lift.	Per well.	Day per pair.	Interest at 3 p c.	Repairs, &c.	Total	Per acre irrigated.	Lifting	Total.						
150	480	347	77	230	1,856	520	264	970	Wheat, ..	2	60 days	10,025	182	5	12 9	4 3	4 3	...	...	10 1	0 0	10 1	113	114	115	116				
153	473	911	124	270	4,394	988	407	410	Wheat, ...	2	70 days	19,230	228	70	10 0	4 5	2 26	...	...	15 3	15 0	30 3	113	114	115	116				
155	557	1,715	168	168	5,500	700	388	1,760	Indurana, .	2	45 days	24,369	211	55	7	7	1 8	...	...	10 5	25 0	35 5	113	114	115	116				
160	545	2,007	81 0	80	5,586	481	208	740 1,050	Barley, ..	{ 2 45 days 2 38 days	{ 20,769 10,130	180	55	5	8 6	8 4	1 1	...	...	10 7	31 0	41 7	113	114	115	116				
166	380	400	129	120	1,628	480	180	660	Carrots, ..	2	..	11,166	142	60	7 8	7 8	1 5	...	...	0 8	30	30 8	113	114	115	116				
167	528	2,017	100	112	6,007	381	223	2,400	Wheat, .	2	40 days	18,010	37	10	10 8	11 4	...	...	...	0 8	30	30 8	113	114	115	116				
170	380	430	110	110	1,403	352	131	810	Barley, ..	2	45 days	8,252	107	70	10 5	10 5	5 37	...	...	10 3	13 0	27 3	113	114	115	116				
173	118	1,113	92	92	3,815	538	320	2,100	Barley, ..	2	50 days	9,892	38	80	17 6	17 0	4 4	...	...	8 1	22	30 1	113	114	115	116				
178	560	1,010	106	106	2,074	438	215	1,960	Wheat, ...	2	60 days	10,931	27	55	12	12	4	...	...	13 1	17 0	30 1	113	114	115	116				
180	570	823	107	107	2,037	392	223	650	Wheat, ..	2	45 days	10,025	20	60	8 7	8 7	4 81	...	...	5 3	11 0	16 3	113	114	115	116				
183	374	817	112	112	2,110	380	220	370	Wheat, ..	2	60 days	6,840	31	10	12 7	12 7	0 1	...	...	5 3	11 0	16 3	113	114	115	116				

TABLE A—*Observation and Experiment—(Continued)*[illegible]

TABLE A.—*Observation and Experiment—(Continued).*

DIPLOMATICA

Date			Class	Cost						Supply	Quality	Substratum	Cultivators on well		Labor and cost per day/annas								
Serial Number	Day	Month		Year	Construction.	Fixings.	Total	Renewal.	Life.				Yearly repairs.	Total	Number	Costo	Men, home.	Do hired.	Rate, per day	Cattle	Cost for men	Do for cattle	Total cost, per day
37	28	30	41	49	40	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
188	28	182	286	Masonry,	250/	0/-	250/-	..	6/-	1/-	10/-	Sprng, ..	Sweet, ..	Clay 30',	1	Writer, Loahus, 1 tankar, 1 fruit seller, 1 tankar, 1 tankar, 10 Loahus, 1 tankar, ..	6	1 15	4 05	12	12	12/3	12/3
192	28	182	305	"	100/	0/	100/	..	5/	2/-	12/-	"	"	" 30',	1	1 tankar, 10 Loahus, 1 tankar, ..	3	..	4 2	0	0	-8/-	-8/-
195	29	182	185	Kacha lined,	14/	8/	17/-	2/-	5/-	1/	8/-	"	"	" 30', ..	1	1 tankar, ..	3	..	4 2	0	0	-8/-	-8/-
199	29	182	508	Masonry,	200/	3/	203/	..	8/	1/-	9/-	"	"	" 30',	1	Pandit, 7 tankars, 1 clerk, 1 tankar, ..	3	1 5	2 45	3	3	-7/6	-7/6
200	30	182	185	"	150/	3/-	153/-	..	8/-	1/-	9/-	"	"	" 24',	1	1 tankar, 10 Loahus, 1 tankar, ..	2	1 25	4 3	0	0	-9/-	-9/-
209	30	182	476	"	100/	3/	103/-	..	8/	4/-	12/-	Percolation,	"	" 24', ..	1	1 Ahir, ..	2	1 25	4 2 31	6	6	-8/3	-8/3
207	31	182	1,128	"	200/	8/-	208/	..	8/-	2/-	10/-	Sprng, ..	"	" 30',	1	1 tankar, 5 Channars, ..	1	2 15	0 3	0	0	-12/-	-12/-
211	31	182	1,189	Dry brck,	150/	0/	150/-	..	8/	1/-	17/-	"	"	" 33',	2	2 Channars, 1 tankar, ..	0	..	0 5	0	0	1/1/-	1/1/-
217	1	282	91	Masonry,	150/	6/-	156/-	..	10/-	1/-	21/-	"	"	" 42', ..	7	7 Musalmen, ..	3	4 20	12 10	18	18	1/12/-	1/12/-
221	1	282	102	"	100/	3/-	103/	..	10/	3/-	13/-	"	"	" 40',	1	1 Musalman, 1 Kachia, 1 tankar, ..	2	1 15	2 25	3	3	-5/6	-5/6
225	2	282	171	"	250/	10/-	260/-	..	10/-	1/-	31/-	"	"	" ..	7	7 Channars, ..	7	..	12 6	18	18	1/8/-	1/8/-

( 14 )

TABLE A—Observation and Experiment—(Continued).

## EXPERIMENTAL.

COMMAND.																				
Kharif 1881-82										Rabi 1881-82										
Serial Number	Run.	Class	Pairs of cattle to each lift	Lift		Depth to Wells			Soil.	Kharif 1881-82					Rabi 1881-82					
				Number	Content in cubic feet.	Morning	Evening	Mean.		Crop	Waterings required.	Area.	Total area reduced to one watering	No. of days to area.	Crop.	Waterings required.	Area.	Total area reduced to one watering	No. of days to area.	
186	Lagor, Kill,	1	2	277 1/2	50 1/2	16 0	22 8	19 7	Dumat,	Sugarcane,	..	..	..	..	..	..	..	..	..	..
192	Lagor,	1	2	288	..	16 6	22 6	19 5	"	"	..	..	..	..	..	..	..	..	..	..
195	Kill,	2	1	..	..	..	..	18	"	"	..	..	..	..	..	..	..	..	..	..
196	" 2 Lift,	1	1	512 1/2	..	18	21 5	19 7 1/2	"	"	..	..	..	..	..	..	..	..	..	..
200	"	2	1	562 1/2	..	11	12	11 1/2	"	"	..	..	..	..	..	..	..	..	..	..
203	"	3	1	506 1/2	..	11	18	11 1/2	"	"	..	..	..	..	..	..	..	..	..	..
207	"	3	1	512 1/2	..	16 6	21	18 8	Matyar,	Cotton,	..	2 3 57	7 14	20	..	..	..	..	..	..
211	"	1 1/2	2	5703 1/2	..	15 5	16 5	16 0	"	"	..	2 2 13	4 86	7	..	..	..	..	..	..
217	"	3	1	7087 1/2	..	13	19 6	15 8	Dumat,	"	..	..	..	..	..	..	..	..	..	..
221	Kill, 2 pairs of cattle generally used,	1	1	6637 1/2	..	9	20	17 1/2	"	"	..	..	..	..	..	..	..	..	..	..
223	Kill,	2	3	..	..	20	..	..	"	"	..	..	..	..	..	..	..	..	..	..



EXPERIMENTAL

WORK.

COST.

Remarks

116

Serial Number	Duration of work, minutes	No of lifts.	Cubic feet lifted				II P	Area irrigated				Depth		Days to an Acre			Annual				Per acre	
			Per pair of cattle per hour	Per lift, per hour	Total per well.	Per bullock.		Total per well.	Interval	Area in square feet.	On area.	Of damp	Per pair of cattle.	Per lift.	Per well.	Duty per pair.	Interest at 5 p c.	Repairs, &c	Total	Per acre irrigated	Lifting	Total
186	592	{ 785 } { 568 }	111 151	2,174 2,967	655 875	788 518	{ 660 } { 660 }	Wheat, .	30 days	33,300	.154	7	53	40	13	..	12 9 19	31 9	112	113	114	115
192	577	1,002	150	2,886	880	508	220	Wheat, .	30 days,	5,630	5	60	155	155	775	..	53 12 0	173	112	113	114	115
195	..	..	..	..	..	..	..	"	30 days,	8,712	..	..	100	100	50	..	08 80	88	112	113	114	115
196	471	385	269	2,122	1,469	936	{ 780 } { 780 }	Oats, Barley, ..	30 days, 30 days,	4,776 9,167	152 152	5	31	31	31	..	101 90	101	112	113	114	115
200	430	232	111	229	1,612	350	120	"	30 days,	10,600	155	75	83	41	20	..	76 90	166	112	113	114	115
203	382	331	133	266	1,601	612	234	Wheat, ..	30 days,	8,708	.191	62	100	50	5	..	51 12 0	171	112	113	114	115
207	352	600	205	616	3,638	1,108	389	"	37 days,	15,140	235	75	846	282	282	..	101 101	201	112	113	114	115
211	337	667	230	345	3,865	.955	322	"	15 days,	30,510	126	16	126	281	142	..	78 17 0	218	112	113	114	115
217	540	500	149	413	4,073	727	397	Barley, .	260 days,	17,082	.290	80	75	25	13	..	78 21 0	288	112	113	114	115
..	..	618	160	180	4,374	800	432	Wheat, .	230 days,	10,557	200	75	78	20	..	..	..	..	112	113	114	115
221	490	501	405	105	8,326	2,052	1,005	"	230 days,	18,603	18	80	233	233	233	..	51 13 0	181	112	113	114	115
225	..	..	..	..	..	..	..	"	..	22,000	..	..	..	..	..	..	130 11 0	410	112	113	114	115



TABLE A — Observation and Expense—(Continued)

## DESCRIPTIVE

Date			Class	Cost					Supply	Quality	Substratum	Cultivators on well		Labor and cost per day in annas						
Serial Number	Month	Year		Construction	Fillings	Total	Renewal	Tolls				Yearly repairs.	Total	Number	Caste	Men, home	Do hired	Rate, per day	Cattle	Cost for men.
229	3	82	Masonry, Kucha lined, Masonry,	200/-	8/	208/-		10/-	4/	14/	Percolation, Sweet,	Sand, {	Chamars, ..	2	..	2	..	..	15/-	
231	.			12/-	5/-	17/-	3/-	10/-	1/-	11/-	Spring, .	"	Clay 37', .	Lodhis, .	2	1	5	9		
234	3	82		300/-	10/-	310/	.	9/-	1/-	28/	"	"	" 40', {	Lodhis, .	6	4	5	6	11/-	
											"	"	"	Herdsmen, }						
238	4	82	Kucha lined,	9/	3/-	12/-	3/	8/-	1/	12/	"	"	" 30', .	Banna, .	2	1	5	3	9/6	
242	1	82	"	5/-	2	7/	2/	9/-	1/-	12/-	"	"	" 30,	Musliman, .	1	2	4	6	9/-	
248	4	82	"	4/-	2/-	6/-	1/-	9/-	1/	11/-	"	"	" 40',	Jat, ..	1	1	2	3	5/6	
251	5	82	"	9/-	2/-	11/	0 5	9/-	0 5	10/-	"	"	" 32', {	Jat, .	1	1	4	6	10/-	
											"	"	"	Brahmins, }	1	2	1			
255	5	82	Masonry,	200/-	4/	204/	.	8/	1/-	17/-	Percolation, Sweet,	Sand, ..	Brahmin, }	2	1	2	3	3	6/-	
259	9	82	"	800/-	20/-	820/	.	9/-	1/-	64/	"	"	"	Chamar, .	2	1	2	3	6/-	
											Spring, .	Clay 75', {	Herdsmen, }	14	3	15	49	9 1/6		
265	9	82	"	800/-	20/-	820/-	..	9/-	1/-	73/	"	"	"	Brahmin, .	13	5	15	48	4 3/6	
268	9	82	"	400/-	10/-	410/-	..	9/	1/-	37/	"	"	"	Kachia, .	4	..	4	6	9/-	
											"	"	"	Herdsmen, }	4	..	4	6	9/-	
275	11	82	"	300/-	0/-	300/-	.	8/-	1/-	17/-	"	"	"	Musliman, }	2	9	1	6	11/6	
											"	"	"	Lodhis, }	2	9	1	6	11/6	

( III )

TABLE A—*Observation and Experiment—(Continued)*

## EXPERIMENTAL

COMMAND										AREA IRRIGATED TO DATE.																				
Kharif 1881-82										Rabi 1881-82																				
Serial Number	Run.	Class	Pairs of cattle to each lift.	Jiff		Depth to Wells		Soil	Kharif 1881-82				Rabi 1881-82				Kharif 1881-82				Rabi 1881-82									
				Number	Feet in cubic	Morning	Evening		Mean	Crop	Waterings required	Area.	Total area reduced to one watering	No of days to area	Crop	Waterings given.	Area.	Working days to date	Per lift	Per pair.	Duty	Crop.	Waterings given	Area.	Working days to date	Per lift	Per pair.	Duty		
229	KIII,	"	1	1	6 6375	17	24	20 5	68	69	Cotton,	2	3 17	6-34	..	3	0 6	65	110	79	Cotton,	1	8 17	11 5	138	85	..	0 6	126	081
231	"	"	2	1	6 6375	17	24	20 5	68	69	"	3	3 17	6-34	..	3	1 51	65	110	79	"	1	8 17	11 5	138	85	..	1 51	171	113
231	"	"	1	1	6 75	18	20	19	68	69	"	3	3 17	6-34	..	3	7 86	65 7	111	79	"	1	8 17	11 5	138	85	..	7 86	178	119
231	"	"	1	1	6 75	18	20	19	68	69	"	3	3 17	6-34	..	3	1 14	65 7	111	79	"	1	8 17	11 5	138	85	..	1 14	224	224
231	"	"	1	1	6 75	18	20	19	68	69	"	3	3 17	6-34	..	3	5 08	65 7	111	79	"	1	8 17	11 5	138	85	..	5 08	223	223
231	"	"	1	1	6 75	18	20	19	68	69	"	3	3 17	6-34	..	3	7 86	65 7	111	79	"	1	8 17	11 5	138	85	..	7 86	244	244
238	"	"	1	1	5 5	26	28	27	68	69	"	3	3 17	6-34	..	3	1 12	8 68	53	79	"	1	8 17	11 5	138	85	..	1 12	371	371
242	"	"	1	1	6 86	26	31	28 5	68	69	"	3	3 17	6-34	..	3	0 8	8 68	53	79	"	1	8 17	11 5	138	85	..	0 8	162	162
242	"	"	2	1	6 86	26	31	28 5	68	69	"	3	3 17	6-34	..	3	0 8	8 68	53	79	"	1	8 17	11 5	138	85	..	0 8	409	409
242	"	"	2	1	6 86	26	31	28 5	68	69	"	3	3 17	6-34	..	3	0 8	8 68	53	79	"	1	8 17	11 5	138	85	..	0 8	302	302
242	"	"	2	1	6 86	26	31	28 5	68	69	"	3	3 17	6-34	..	3	0 8	8 68	53	79	"	1	8 17	11 5	138	85	..	0 8	383	383
242	"	"	2	1	6 86	26	31	28 5	68	69	"	3	3 17	6-34	..	3	0 8	8 68	53	79	"	1	8 17	11 5	138	85	..	0 8	162	162
242	"	"	2	1	6 86	26	31	28 5	68	69	"	3	3 17	6-34	..	3	0 8	8 68	53	79	"	1	8 17	11 5	138	85	..	0 8	409	409
242	"	"	2	1	6 86	26	31	28 5	68	69	"	3	3 17	6-34	..	3	0 8	8 68	53	79	"	1	8 17	11 5	138	85	..	0 8		

TABLE A — Observation and Experiment—(Continued).

## EXPERIMENTAL

EXPERIMENTAL

Serial Number	Work										Cost										Remarks.																				
	Duration of work, minutes					H P					Area Irrigated					Days to an Acre						Per Acre.																			
	Cubic feet lifted.					II P					Length of watercourse					Crop						Depth.					Per pair of cattle.					Annual					Per Acre.				
	No of lifts.	Per pair of cattle, per hour	Per lift, per hour	Total per well.	Per bullock.	Total per well.	Length of watercourse	100	Watering	Interval	Area in square feet.	On area.	Of damp	107	Per lift.	Per well.	Duty per pair	Interest at 5 p c.	Repairs, &c.	Total		Per acre irrigated.	Lifts	Total																	
220	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1-7	..	11 038 0	30 0	..	..	..	..	..																	
231	501	358	141	282	2,376	801	431	160	Wheat, ..	330 days, ..	15,015	15	70	2 P	..	..	..	..	..	..	..	..	..	..																	
231	552	380	279	2,606	1 107	770	790	Barley, ..	3 80 days, ..	15,360	31	10	45	17	15 5	28 0	45 5	..	..	..	..	..	..	..																	
231	400	318	180	1,164	910	448	320	Tobacco, ..	2 ..	3,886	21	1 10	5 P	..	..	..	..	15 5	28 0	45 5	..	..	..	..																	
238	428	231	170	1,270	1 270	515	300	Barley, ..	3 35 days, ..	6,830	18	8	0 2	0 2	..	..	..	0 0	12 0	12 0	..	..	..	..																	
212	407	280	127	261	1,082	1 000	467	Wheat, ..	3 60 days, ..	6,021	120	60	57	2 85	..	..	..	0 4	12 0	12 1	..	..	..	..																	
212	..	..	..	..	..	..	..	Garlic, ..	6 15 days, ..	6,130	120	75	..	..	..	..	..	..	..	..	..	..	..	..																	
218	..	..	..	..	..	..	..	Wheat, ..	4 ..	6,148	..	..	0 75	0 75	..	..	..	0 3	11 0	11 3	..	..	..	..																	
251	500	397	145	200	2,850	1 471	808	Barley, ..	3 60 days, ..	2,010	38	60	11 2	5 6	..	..	..	0 6	10 0	10 6	..	..	..	..																	
255	523	320	190	106	1,165	2 574	1,166	Wheat, ..	3 60 days, ..	2,066	38	80	..	..	..	..	..	..	..	..	..	..	..	..																	
480	216	108	108	1,318	2 223	1,067	680	Khurfi, ..	2 6 days, ..	12,000	113	3	3 5	3 5	..	..	..	10 2	17 0	17 2	..	..	..	..																	
250	480	220	120	252	13,888	1 116	550	Barley, ..	2 30 days, ..	4,371	3	85	10	..	..	..	..	11 0	61 0	10 5	..	..	..	..																	
205	180	2,100	116	232	11,880	1 200	571	Wheat, ..	2 ..	22,000	27	80	12 0	6 3	..	..	..	41 0	73 0	11 4	..	..	..	..																	
205	..	..	..	..	..	..	..	Barley, ..	2 ..	31,328	37	90	..	..	..	..	..	..	..	..	..	..	..	..																	
208	510	732	233	233	4,200	1 722	380	Wheat, ..	3 60 days, ..	13,420	31	75	0 4	0 1	..	..	..	20 5	37	57 5	..	..	..	..																	
208	540	771	270	270	4,853	2 000	1,079	"	3 60 days, ..	17,990	31	80	4 0	1 5	..	..	..	..	..	..	..	..	..	..																	
275	510	714	220	220	5,731	1 025	682	Barley, Penna, ..	3 60 days, ..	20,812	180	1 0	3 21	1 02	..	..	..	15 5	17 0	32 3	..	..	..	..																	

TABLE A — Observation and Experiment—(Continued.)

Locality		Year	Area in Acres			Cultivated Area			Percentage of Total Cultivated Area										Irrigation Wells			Average area per lift, in acres			Remarks																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
			Actual area in acres.	Waste.	Culturable	Percentage of actual area cultivated	Double cropped area in acres	Total area actually cultivated in the year	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Total	Wet	Dry	Total	Wet					Dry	Total	Usual labor for lifting 6 buckets	Kharrif	Rabi	Total																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
Serial Number	District	Parganna	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
287		Sadabad, "	981 25	12 4	9 8	77 8	45 15	811 10	14 7	85 3	0 4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..</

TABLE A.—Observation and Experiment—(Continued)

## DESIGNATIVE

Serial Number	Date		Class	Cost					Supply	Quality	Substratum	Cultivators on well	Labor and cost per day in annas										
	Day	Month		Year	Number of Well.	Cost																	
						Construction.	Fittings.	Total.					Renewal	Latins.	Yearly repairs.	Total.							
37	36	9	40	41	18	4	15	40	47	18	40	51	52	53	54	55	56	57	58	59	60	61	
279	11	282	240	Masonry, 1st year,	300/	3/-	300/	..	9/-	1/-	10/-	Spring, ..	Clay, 45', ..	1	Lotha, ..	2	1 15	1	25	0	0	0	-8/6
283	11	282	190	Kucha unlined, 1 years' old, ..	5/5	5/	6/	..	9/-	1/-	10/	" ..	" ..	{ 3	Musalmen, ..	..	1 15	4	3	6	6	6	-10/-
287	6	282	224	Kucha lined with wood, 3 years' old,	21/5	4/	21/5	..	10/-	1/-	11/	" ..	" 50', ..	1	Brahmin, ..	..	2 175	2	4	3	3	3	-7/-
291	6	282	118	Kucha lined with wood, 15 years' old,	21/5	4/	24/5	..	8/-	1/-	9/	" ..	" 50', ..	1	Gujar, ..	1	2 15	2	3	3	3	3	-6/-
294	6	282	65	" .. now,	21/5	4/-	24/5	..	8/-	1/-	9/-	" ..	" 48', ..	1	Brahmin, ..	3	..	2	2	3	3	3	-5/-
298	6	282	1,798	Masonry, 200 years' old,	400/	6/	106/	..	8/	1/-	17/-	Slightly Kharra, ..	" ..	{ 4	Jata, ..	2	5 15	4	85	6	6	6	-14/6
300	7	282	370	Masonry, old, ..	400/	6/	406/	..	8/	3/	10/	Percolation,	Sand, ..	2	Brahmins, ..	..	5 20	4	10	6	6	6	1/-
304	7	282	385	Kucha lined, 0 months' old, ..	75	15	9/	1/	8/-	1/-	10/	" ..	" ..	1	Brahmin, ..	1	2 13	2	25	3	3	3	-5/8
307	7	282	1,221	Masonry, 60 years' old,	1000/	6/	1006/	..	9/	1/-	19/	Spring, ..	Clay, 78', ..	1	Jat, ..	1	2 13	4	26	6	6	6	-8/-
312	8	282	8,107	Masonry, ..	300/	3/	303/	..	8/-	10/-	18/-	Percolation was spring,	" 68', ..	1	Dyragi, ..	..	2 15	2	35	3	3	3	-9/6
315	8	282	6,019	Kucha lined, 0 years' old, ..	6/	2/	8/	1/-	95	15	11/-	Spring, ..	" 68', ..	1	Brahmin, ..	2	1 10	4	2	6	6	6	-18/-
919	8	282	6,018	Masonry, ..	400/	4/-	405/	..	8/-	3/-	19/-	Percolation was spring,	" 68', ..	{ 1	Jat, ..	2	2 15	1	4	6	6	6	-10/-

( IIIA )

**TABLE A --- Observation and Experiment --- (Continued)**

## EXPERIMENTAL

[illegible]



TABLE A.—*Observation and Experiment—(Continued).*

## EXPERIMENTAL.

Work														Cost.				Remarks.						
Cable feet lifted				II T		Length of watercourse.	Area irrigated				Days to an acre.				Annual.				Per Acre.					
Duration of work min's.	No. of lifts.	Per pair of cattle per hour	Per lift, per hour	Total per well.	Per bullock.		Total per well.	Crop	Watering.	Interval.	Area in square feet.	Depth.		Per pair of cattle.	Per lift.	Per well.	Duty per pair.		Interest at 5 p. c.	Repairs, &c.	Total.	Per acre irrigated.	Lifting	Total.
												On area.	Of damp.											
279	400	150	300	2,295	1 380	631	600	Carrots, ..	3 20 days,	15,207	15	.70	58	20	20	20	..	15.1	10.0	25.1	113	114	115	
283	..	..	..	..	..	..	..	Rabi, ..	"	12,000	..	..	72	30	30	30	..	0.3	10.0	10.3	..	..	..	
287	460	100	100	1,481	2 607	1,200	{ 101 100	Ghelana, .. Wheat, ..	4 30 days, 4 30 days,	8,803 2,211	131 131	1 0 66	4	4	4	4	..	10.2	11.0	21.2	..	..	..	
291	552	394	202	1,862	2 710	1,510	520	Barley, ..	1 ..	7,811	.238	90	55	55	5.5	..	..	10.2	9.0	19.2	..	..	..	
295	..	..	..	..	..	..	2	Wheat, ..	3 ..	0,220	..	..	7	7	7	7	..	10.2	0.0	19.2	..	..	..	
296	..	..	..	..	..	..	450	Wheat, ..	0 ..	41,400	..	80	0.3	3.15	1.05	..	..	20	17.0	37.3	..	..	..	
300	400	371	102	1,505	1 778	816	1,020	Wheat, ..	2 07 days,	0,350	.218	70	1 1	14	7	..	..	20.3	10.0	30.3	..	..	..	
301	..	..	..	..	..	..	500	Barley, ..	2 ..	0,120	..	00	7	7	7	..	..	0.1	10.0	10.4	..	..	..	
307	415	291	122	213	1,800	2,188	971	500	Wheat, ..	13,021	.138	50	0.7	3.31	3.31	..	..	..	..	..	..	..	..	
312	510	231	71	117	1,217	1 330	078	570	Wheat, ..	10,017	121	00	8.7	4.33	4.33	..	..	..	..	..	..	..	..	
325	525	231	131	131	1,113	2 070	1,087	{ 120 50	Wheat, .. Garden, ..	5,081 820	.170	1.10	0.7	0.7	0.7	..	..	15.1	18.0	33.1	..	..	..	
315	520	307	102	201	1,876	1 022	892	{ 470 210	Chajal, .. Wheat, ..	7,185 5,540	.110 1.20	.80	0.8	3 1	3 4	..	..	0.1	11.0	11.4	..	..	..	
319	610	401	122	122	2,400	2 000	1,512	010	Wheat, ..	8,920	279	80	9 0	0 0	4 8	..	..	20.2	10.0	30.2	..	..	..	

TABLE A.—Observation and Experiment—(Continued).

## STATISTICAL

STATISTICAL																																		
Locality			Percentage of Total Cultivated Area										Irrigation Wells										Lifts			Average area per lift in acres			Remarks.					
Serial Number	Perganna	Village	Area in Acres			Cultivated Area			Kharif				Rabi			Lime masonry.	Dry bricks.	Kucha.	Total.	Leather bucket	Earthen pots.	Total	Usual labor for lifting buckets.	Kharif	Rabi	Total								
			Actual area in acres	Waste.	Culturable.	Percentage uncultivated	Area cultivated	Double cropped area in acres	Total area actually cultivated in the year	Wet.	Dry	Wells.	Canals	Other sources.	Wet												Dry	Wells.		Canals	Other sources.	Total		
			Year	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		25	26	27	28	29	30	31	32	33	34	35	
329	Dindl,	Daynipur,	1879 80	513 45	6 5	6 4	87 1	10 70	457 37	35 7	64 2	..	..	..	61 4	61 4	85 7	..	..	29 38 6	2 p 4	..	2 p-1	88	48	48	..	48	..	..	382	382	382	W. S fallen 15'.
330	"	"	80 81	513 46	6 5	6 6	86 9	21 49	467 07	44 1	55 9	14 5	..	..	47 0	61 5	29 6	..	..	89 38 5	2 p 4	..	1 p-33	40	49	49	..	49	..	..	139	282	421	"
331	Anupshahr,	Anupshahr,	79 80	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Kucha wells do not require any lining.
	"	"	80 81	419 22	4 9	0 9	94 2	11 0	434 4	16 7	88 3	..	0 2	..	40 8	41 0	1 1	15 4	..	42 5	59 0	..	..	..	8	4	4	..	4	..	..	121	121	..
	"	"	79 80	1761 88	38 8	10 6	50 6	84 5	976 15	14 4	85 6	2 6	1 6	0 25	52 4	66 85	5 5	4 4	0 06	28 2	39 15	3 p-1	1 p-4	12	58	32	12	44	..	0 80	1 42	2 22	..	
	"	"	80 81	1761 88	38 7	14 4	46 9	104 72	929 78	20 2	79 8	5 8	2 19	..	52 5	60 49	6 8	5 4	0 01	27 8	39 51	1 p-41	1 p-4	16	62	32	16	48	Men,	1 71	1 69	3 40	..	
316	"	Gynah,	79 80	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2 pairs of cattle per lift generally used.
	"	"	80 81	1296 75	6 3	21 7	72 0	98	10 31	83 7	66 3	9 7	..	..	37 0	46 7	24 0	..	..	29 3	48 3	8 p-1	2 p 2	2 p-6	14	34	..	84	Bullock,	2 98	7 27	10 20	..	
337	Burna,	Chandpur,	79 80	701 8	15 0	5 9	78 2	263 8	802 11	53 2	46 8	2 0	16 2	..	25 9	44 1	19 7	15 2	0 10	20 9	55 9	3 p 1	..	2 p 6	20	28	..	28	"	0 58	5 64	6 22	W S has risen 6' since canal was opened.	
	"	"	80 81	701 8	15 7	5 7	78 6	228 75	779 72	70 7	29 3	12 0	13 4	0 10	20 9	46 4	26 5	18 7	..	8 4	58 6	3 p 1	..	2 p-13	20	28	..	28	"	3 27	7 39	10 66	2 pairs cattle used.	
339	"	Taturpur,	79 80	332 0	5 7	5 5	88 3	71 41	365 86	40 9	59 1	16 6	..	..	26 6	43 2	24 3	..	..	32 5	56 8	..	..	2 p-1	12	13	..	13	"	4 68	6 31	11 49	2 pairs of cattle per lift generally used.	
	"	"	80 81	332 0	6 1	1 4	92 5	88 37	395 37	53 6	46 4	10 1	..	..	22 5	41 0	34 2	..	0 3	28 9	58 4	..	..	1 p-11	..	..	..	..	"	..	..	10 52	..	

TABLE A.—*Observation and Experiment—(Continued).*

DESCRIPTIVE

Date			Class.	Cost						Supply.	Quality	Substratum	Cultivators on well		Labor and cost per day in annas									
Serial Number	Day	Month		Construction.	Fixings.	Total	Renewal	Tools.	Yearly repairs.	Total					Number	Casto	Men, home.	Do hired	Rate, per day	Cattle.	Cost for men	Do for cattle	Total cost, per day	
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
325	8	282	8,445	Kucha lined, ..	11/	0/-	17/	.	7/-	1/-	15/-	Spring,	Sweet,	.	Clay,	.	1 Jat,	..	1 2 1 5	4	3	0	0	-9/-
329	13	282	118	Kucha unlined, ..	8/	3/-	22/	..	7/-	1/-	15/-	"	"	..	" 42',	{	1 Thakur, 2 Lodhas,	.	3 .. ..	4 4 ..	4 4 ..	12	..	11/-
334	14	282	768	Masonry, ..	250/	3/-	253/	..	7/-	1/-	8/-	"	"	..	"	.	1 Mali,	.	3 .. ..	2 2	3	3	-56/-	
340	14	282	1,088	"	300/	9/-	309/-	..	7/-	1/-	22/	"	"	..	" 39', ..	1 Mali,	.	3 1 1 5	8 3 5	12	12	-15/6		
346	15	282	510	"	300/	10/-	310/	..	8/-	1/-	25/-	"	"	..	" 30',	{	1 Barber, 1 Beni, 3 Brahmins, 9 Jats,	.	3 .. ..	1 2	6	6	-8/-	
353	16	282	158	Kucha lined with wood,	37/	3/-	40/-	..	8/-	2/-	10/-	"	"	..	" 27', ..	1 Lodhas,	.	3 .. ..	4 2	6	6	8/-		
359	20	282	234	"	24/	6/-	30/	3/-	11/-	1/-	26/-	"	"	..	"	{	1 Barber, 2 Jats, 6 Brahmins,	.	3 2 1 5	8 5	12	12	111/-	

TABLE A.—Observation and Experiment—(Continued).

EXPERIMENTAL.

COMMAND.

AREA IRRIGATED TO DATE

Serial Number	Run	Depth to Wells			Soil	Kharif 1881-82							Rabi 1881-82							Kharif 1881-82							Rabi 1881-82																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
		Class	Pairs of cattle to each lift.	Number.		Content in cubic feet.	Crop.	Waterings required.	Area.	Total area reduced to one watering.	No. of days to area.	Crop.	Waterings required.	Area.	Total area reduced to one watering.	No. of days to area.	Crop.	Waterings given.	Area.	Working days to date.	Per hft.	Per pair.	Duty	Crop.	Waterings given.	Area.	Working days to date.	Per hft.	Per pair.	Duty																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
322	KIII,	..	1	2	4.80	..	..	..	..	..	Barley, .. " & Peas, Gujal, ..	2 3 3	0.32 9.16 0.71	217	56	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

TABLE A.—*Observation and Experiment—(Continued).*

EXPERIMENTAL.																											
WORK.																	COST.										
Serial Number	Duration of work, minutes.	No of lifts.	Cubic feet lifted.			H P.		Length of watercourse.	Area Irrigated.				Depth.		Days to an Acre			Annual			Per Acre			Remarks.			
			Per pair of cattle, per hour	Per bullock, per hour	Total per well.	Per bullock.	Total per well.		Crop.	Watering	Interval.	Area in square feet.	On area.	Of damp.	Per pair of cattle.	Per lift.	Per well.	Interest at 5 p. c.	Repairs, &c.	Total.	Per acre irrigated.	Lifting	Total.				
325	555	502	110	140	2,600	2 288	1,207	550	Darley Penns,	2	60 days.	16,524	157 1-2	52	52	26	.	.	08	15 0	15 1	112	117	114	115	No experiment on account of rainfall.	
329	..	..	..	..	..	..	..	..	Rabi,	..	2	60 days.	10,754	..	10-1	5-2	26	..	..	08	15 0	15 1	112	117	114		115
331	..	..	..	..	..	..	..	..	Garden,	..	..	9,231	..	47	47	47	.	.	12 0	80	20 6	112	117	114	115		
340	..	..	..	..	..	..	..	..	Rabi,	3	..	18,235	..	30	18	15	..	..	15-4	22-0	37 1	112	117	114	115		
346	400	426	190	380	2,550	1 271	508	790	Tobacco,	1	..	10,706	24	67	80	4	13	.	15 1	27 0	10 0	112	117	114	115	Only one lift at work as rain had recently fallen.	
351	..	..	..	..	..	..	..	..	Rabi,	2	..	10,311	..	80	10	40	..	..	20	10	12 0	112	117	114	115		
355	530	520	82	105	5,457	600	372	810	Garden,	2	25 days.	22,080	15 1-4	70	38	10	..	..	10	26	27 3	112	117	114	115		

TABLE A—*Observation and Experiment—(Continued).*

[illegible]

TABLE A.—*Observation and Experiment—(Continued)*

## DESCRIPTION

Serial Number	Date	Class	Cost						Supply	Quality	Substratum	Cultivators on well		Labor and cost per day: manures									
			Construction.	Fittings.	Total.	Renewal	Tools	Yearly repairs				Total.	Number	Caste.	Men, home Do hired	Rate, per day	Cattle.	Cost for men	Do for cattle	Total cost, per day			
37	1883	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
369	20	282	215	Kucha unlined,	5 5	3/	8 5	5 5	8/-	..	135/-	Springs, ..	Sweet,	Clay, ..	{ 1 Musalman, 1 Brahmin, }	1	2 20	4 4	0	10/-			
374	21	282	193	Masonry,	300/	0/	306/-	..	7/-	1/-	15/-	"	"	"	{ 12 Jats, 2 Chamars, }	4	2 15	8 6	12	1 1/2/-			
381	22	282	137	Kucha, lined with wood,	32/	35/	..	9/-	10/-	1/	10/-	"	"	"	1 Lodha,	2	1 15	4 25	0	18/5			
386	22	282	354	" "	32/	35/	..	9/-	10/-	1/	10/-	"	"	"	8 Lodhas,	..	3 1 10	4 2	6	18/-			
389	24	282	2,300	Masonry, old, ..	250/	6/	256/-	..	9/	1/-	19/-	"	"	"	{ 8 Lodhas, 1 Musalman, }	3	2 15	8 5	12	1 1/-			
391	25	282	1,214	" 8 years,	200/-	3/-	203/-	..	10/-	1/-	11/-	"	"	"	38, .. 12 Ahirs,	4	..	4 3	6	19/-			
400	25	282	1,091	Masonry, old, ..	200/-	3/-	203/-	..	9/-	1/-	10/-	"	"	"	.. 13 Ahirs,	3	..	4 2	0	18/-			
106	26	282	1,459	Kucha unlined, ..	5/	5/	10/-	1/-	9/	1/-	11/-	"	"	"	20, .. 4 Thinggas,	3	1 20	1 4	6	10/-			
410	26	282	1,581	Kucha, lined with wood,	16/	5/	21/-	..	9/-	1/-	10/-	"	"	"	{ .. 115 110 1075 1045 105	..	1 15 1 10 1075 1045 105	4 375	0	..			
412	..	1,581	123/-	Masonry, 4 years,	123/-	5/-	130/-	..	9/-	1/	10/-	"	"	"	.. 0	{ 110 205 110 110 110	2	1 10 1 10 1 10 1 10 1 10	4 20	0	1 7 3		
414	..	1,597	175/	" "	175/	5/	180/-	..	9/-	1/	19/	"	"	"	..	{ 2 1105 105	2	1 10 1 10 1 10	1 25	0	..		

TABLE A.—Observation and Experiment—(Continued).

EXPERIMENTAL.

COMMAND															AREA IRRIGATED TO DATE.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
Kharif 1881-82															Rabi 1881-82																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
Serial Number	Run	Class	Lift			Depth to Wells			Soil	Kharif 1881-82					Rabi 1881-82					Kharif 1881-82					Rabi 1881-82																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
			Pairs of cattle to each lift	Number	Content in cubic feet	Morning	Evening	Mean		Crop	Waterings required	Area.	Total area reduced to one watering	No. of days to area.	Crop.	Waterings required	Area.	Total area reduced to one watering	No. of days to area.	Crop	Waterings given.	Area.	Working days to	Per lift.	Per pair.	Crop	Waterings given	Area.	Working days to	Per lift.	Per pair.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
369	Kili,		2	1	5 70	27	28	27 5	Dumat,																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	</

\* Area small as drinking water was taken from the lifts

† Since rains

‡ Since rain.

§ 14 feet to day.



TABLE A — *Observation and Experiment—(Continued)*

## EXPERIMENTAL

EXPERIMENTAL

Work.																									Cost.					Remarks																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
Serial Number	Duration of work, minutes.		No of lifts.		Cubic feet lifted				H P		Length of watercourse.	Area irrigated				Depth		Days to an acre				Annual		Per acre																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
	52	53	54	55	56	Total per well	Per bullock.	Total per well.	57	58		59	Crop.	100	101	102	103	On area.	Of damp	106	107	Per lift.	Per well.	Duty per pair.	Interest at 5 p c.	Repairs, &c.	Total.	Per acre irrigated	Lifting		Total																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
369	437	429	162	324	2,362	1 163	501	450	Tobacco, ..	2	5 days.	20,000	118	60	1 1	22	22	.	0 4	13 5	13 5																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						

Only 2 lifts working on account of recent rain fall.

Field was high and sandy

TABLE A—*Observation and Experiment—(Continued).*

STATISTICAL.																															
Locality				Area in Acres				Cultivated Area				Percentage of Total Cultivated Area										Irrigation Wells				Lift		Average area per left in acres			Remarks.
Parganna.	Village	Year	Actual area in acres	Waste.	Percentage uncultivated	Percentage of actual area cultivated	Double cropped area in acres	Total area actually cultivated in the year	Wet.	Dry	Wells.	Canals	Other sources	Dry	Total	Wet.	Canals.	Other sources.	Dry	Total	Lime masonry	Dry bricks.	Kucha.	Leather bucket.	Karthan pots.	Total	Usual labor for lifting buckets	Kharat.	Rabi.	Total	
225	Seerwah,	1879 80	2576 17	8 2	11 0	79 9	412 0	2549 86	39 6	60 4	12 8	..	007	30 6	43 4	26 6	..	0 2	29 8	50 6	3 p-3 2 p-10 1 p-31	..	27	62 85	86	Bullock,	3 85	8 00	11 85	2 pairs of cattle per lift generally used	
440	"	80 81	2676-17	8 1	12 0	79 3	425 66	2546 86	50 36	49 54	22 2	..	5	28 8	46 0	27 6	..	0 6	26 34	54 0	4 p-3 2 p-1 2 p-1	..	27	..	88	..	6 42	8 00	14 42	"	
441	"	80 81	720 72	5 0	5 6	89 4	60 22	764 42	15 8	84 2	7 8	..	3	45 5	53 1	8 2	..	..	38 7	46 3	4 p-3 2 p-1 2 p-1	..	27	7 19	19	..	3 00	3 2	6 2	"	
442	Meerut,	79 80	1890 8	21 3	16 3	62 4	1438 0	4189 26	68 1	31 0	18 08	1 4	0 02	23 1	42 6	48 0	4 7	..	8 8	57 4	1 p-265 2 p-8	142	415	100	142	242	3 87	8 14	11 51	"	
443	"	80 81	4890 8	22 5	12 9	64 6	1408 26	4567 0	61 0	39 0	19 8	1 6	..	23 8	45 2	36 7	2 9	..	16 2	54 8	1 p-265 2 p-8	142	415	90	142	237	3 94	7 22	11 16	"	
444	Khatauli,	79 80	2179 0	15 7	9 9	71 1	282 57	1228 82	59 9	46 1	3 4	15 6	0 7	32 6	52 3	54 5	28 7	0 05	13 5	47 7	1 p-7	90	97	7 90	97	..	10 99	1 2	2 19	"	
445	"	80 81	2179 0	16 6	10 1	73 3	750 3	2167 95	39 8	60 2	3 0	16 5	0 7	28 5	49 7	31	16 2	0 3	36 7	56 8	1 p-7	90	97	7 90	97	..	0 70	0 8	1 5	"	
446	Roorkhee,	79 80	1970	50 4	3 4	45 2	235	1145	6 6	93 4	25	0 7	..	49 8	52 8	24	1 0	48 8	47 2	87	1 p-7	25	122	9 9	18	..	1 61	1 55	3 16	"	
447	"	80 81	1970	48 8	3 4	47 1	288	1221	6 5	94 5	1 6	0 8	..	40 5	42 9	2 6	0 5	..	54 0	57 1	87	25	122	9 9	18	..	1 11	1 72	2 83	"	
448	Nurpur,	79 80	2115 81	8 4	16 1	75 5	119 7	1848 2	63	93 7	6 0	..	..	54 5	60 5	3	..	..	39 2	39 5	..	55	55	12 43	55	..	2 04	0 10	2 14	"	
449	"	80 81	2115 81	9 4	15 6	75 0	119 7	1864 2	5 4	94 6	5 0	..	..	47 4	52 4	4	..	..	47 2	47 6	..	51	51	11 40	51	..	1 92	0 16	2 08	"	
450	Chandpur,	79 80	1863 0	6 8	6 6	86 6	278 97	1891 76	10 0	90 0	9 8	..	..	38 8	48 6	0 01	..	0 2	51 2	51 4	2	41	43	39	..	..	4 42	..	4 42	Nearly all sugarcane irrigation	
451	"	80 81	1863 0	6 7	7 5	85 5	191 8	1784 36	4 6	95 4	4 5	..	..	56 6	61 1	0 10	..	..	38 8	38 9	2	9	11	11	..	..	9 3	0 21	9 41	"	

TABLE A.—*Observation and Experiment—(Continued)*

[illegible]

TABLE A—*Observation and Experiment—(Continued)*

COMMAND										AREA IRRIGATED TO DATE																					
Run					Kharrif 1881-82					Rabi, 1881-82.					Kharrif 1881-82					Rabi, 1881-82											
Serial Number	Class	Pairs of cattle to each lift	Lift		Depth to Wells		Soil	Kharrif 1881-82					Rabi, 1881-82.					Kharrif 1881-82					Rabi, 1881-82								
			Number	Content in cubic feet	Morning	Evening		Mean	Crop	Waterings required	Area.	Total area reduced to one watering	No of days to area	Crop	Waterings required	Area.	Total area reduced to one watering	No of days to area	Crop	Waterings given	Area.	Working days to date.	Per lift	Per pair	Duty	Crop	Waterings given	Area.	Working days to date.	Per lift	Per pair
419	Kull, 2 par.	2	61	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92
420	"	2	2	2	20	20	20	Dumat	Cotton	8	77	64	128	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	8	047	61.5	123	Cotton	5	775	80	242	121	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	2	047	1	470	235	
421	"	2	2	523	20.5	27.5	24	{ Sandy, Dumat	Sugar, Cotton	8	775	64	128	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	8	047	61	123	Sugar, Cotton	5	775	80	242	121	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	2	047	4	470	235	
422	"	2	2	523	20.5	27.5	24	{ Sandy, Dumat	Sugar, Cotton	8	775	64	128	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	8	047	61	123	Sugar, Cotton	5	775	80	242	121	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	2	047	4	470	235	
423	"	2	2	523	20.5	27.5	24	{ Sandy, Dumat	Sugar, Cotton	8	775	64	128	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	8	047	61	123	Sugar, Cotton	5	775	80	242	121	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	2	047	4	470	235	
424	"	2	2	523	20.5	27.5	24	{ Sandy, Dumat	Sugar, Cotton	8	775	64	128	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	8	047	61	123	Sugar, Cotton	5	775	80	242	121	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	2	047	4	470	235	
425	"	2	2	523	20.5	27.5	24	{ Sandy, Dumat	Sugar, Cotton	8	775	64	128	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	8	047	61	123	Sugar, Cotton	5	775	80	242	121	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	2	047	4	470	235	
426	"	2	2	523	20.5	27.5	24	{ Sandy, Dumat	Sugar, Cotton	8	775	64	128	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	8	047	61	123	Sugar, Cotton	5	775	80	242	121	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	2	047	4	470	235	
427	"	2	2	523	20.5	27.5	24	{ Sandy, Dumat	Sugar, Cotton	8	775	64	128	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	8	047	61	123	Sugar, Cotton	5	775	80	242	121	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	2	047	4	470	235	
428	"	2	2	523	20.5	27.5	24	{ Sandy, Dumat	Sugar, Cotton	8	775	64	128	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	8	047	61	123	Sugar, Cotton	5	775	80	242	121	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	2	047	4	470	235	
429	"	2	2	523	20.5	27.5	24	{ Sandy, Dumat	Sugar, Cotton	8	775	64	128	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	8	047	61	123	Sugar, Cotton	5	775	80	242	121	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	2	047	4	470	235	
430	"	2	2	523	20.5	27.5	24	{ Sandy, Dumat	Sugar, Cotton	8	775	64	128	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	8	047	61	123	Sugar, Cotton	5	775	80	242	121	Barley, Wheat, Oats, Carrots, Garden, Peas, Wheat, Gram,	2	047	4	470	23	

• Incorrectly stated, area seems low, accepted correct.

† Field in ridges

TABLE A — Observation and Experiment—(Continued).

EXPERIMENTAL

Serial Number	Work.										Cost										Remarks.			
	Duration of work.			Cubic feet lifted			H P		Area irrigated			Depth.		Days to an acre			Annual			Per Acre				
	minutes.	No. of lifts	Per pair of cattle, per hour	Per lift, per hour	Total per well	Per bullock	Total per well	Length of watercourse	Crop	Watering	Interval	Area in square feet.	On area.	Of damp	Per pair of cattle.	Per lift.	Per well.	Duty per pair.	Interest at 5 p c	Repairs, &c.		Total	Per acre irrigated	Total
92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	
419	.	.	..	..	..	..	..	Rabi,	.	.	22,000	..	..	80	40	20	.	15 3	17 0	32 3				
425	030	1,264	157	315	0,610	1,111	700	1,020	Wheat,	3	60 days,	22,000	80	30	80	40	20	..	15 3	17 0	32 3			
430	016	1,090	180	301	1,160	1,300	800	1,130	Barley, Guchanna,	..	80 days, 2 90 days,	28,572 10,268	25 25	20 70	60	30	1-0	..	20 5	25 0	45 5			
434	550	512	150	300	2,710	1,070	587	270	Wheat,	2	80 days,	10,880	25	75	684	342	1 71	.	15 3	17 1	32 3			
439	510	572	163	318	2,800	1,178	711	560	"	2	80 days,	11,600	20	66	2-20	1-13	0 56	.	15 3	17 1	32 3			
444	535	706	170	340	3,037	1,482	738	640	Potatoes,	..	4 60 days,	38,577	08	75	2 20	1 13	0 56	.	15 3	17 1	32 3			
449	593	577	198	386	3,831	916	503	1,020	Wheat,	2	60 days,	4,907	1	61	71	37	3 7	}	7 0	10	17 0			
453	053	631	153	386	4,203	947	619	1,020	"	2	60 days,	13,557	31	66	64	32	3 2	}	7 0	10	17 0			
459	700	1,358	130	522	6,111	680	440	800	Sugar,	1	..	20,770	29	10	84	21	21	..	52	90	142			
467	495	640	183	363	1,510	570	480	500	Wheat,	4	30 days,	14,676	..	..	60	30	30	..	52	90	142			
471	540	587	114	228	2,017	770	416	175	Potatoes,	3	20 days,	16,175	10	80	287	287	2 87	..	08	70	78			
475	..	..	..	..	..	..	..	..	Garden,	3	8 days,	21,131	10	80	40	20	20	..	51	70	131			
479	..	..	..	..	..	..	..	..	Sugar,	3	..	9,200	..	..	50	50	50	..	03	00	68			
483	..	..	..	..	..	..	..	..	"	3	..	7,000	..	..	62	62	62	..	03	00	63			
485	..	..	..	..	..	..	..	..	"	3	..	6,500	..	..	70	70	70	..	03	00	68			
489	..	..	..	..	..	..	..	..	"	3	..	9,000	..	..	50	50	50	..	03	00	63			
493	520	1,383	..	40	350	400	205	100	Garden,	..	..	0,453	054	80	..	70	70	..	03	30	33			
495	220	559	..	31	114	300	96	60	"	..	..	3,400	033	60	..	12 6	12 6	..	03	30	33			
497	737	1,381	78	313	3,810	302	267	660	Sugar,	..	..	17,578	22	75	9 6	24	24	..	05	00	65			
499	776	1,411	100	400	5,015	502	380	1,380	"	1	..	25,208	220	60	80	20	20	..	05	00	65			
503	705	1,260	88	353	4,678	382	303	2,030	Wheat,	1	..	11,318	34	75	12 8	32	32	..	05	00	65			
505	..	..	..	..	..	..	..	..	"	1	..	14,800	..	..	00	30	30	..	04	50	50			
507	..	..	..	..	..	..	..	..	"	1	..	14,800	..	..	00	30	30	..	04	50	50			

TABLE A—Observation and Experiment—(Continued)

Locality		Area in Acres				Cultivated Area				Percentage of Total Cultivated Area.										Irrigation Wells				Lifts				Average area per lift, in acres			Remarks						
		Actual area in acres.	Percentage uncultivated.		Culturable.	Percentage of actual	Double cropped area in acres	Total area actually cultivated in the year	Wet.	Dry.	Kharif			Rabi			Lime masonry	Dry bricks.	Kacha.	Leather bucket.	Kharren pots.	Total.	Usual labor for lifting in buckets.	Kharif.	Rabi.	Total											
Waste.	Percentage		Wells.	Canals.							Other sources.	Wells.	Canals.	Other sources.	Wells.	Canals.											Other sources.	Wells.	Canals.	Other sources.	Total	Dry	Wet	Total			
Serial Number	Province	Dist.	Parganna	Village	Year	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
480	Mondwari	Chundpur	Rajndpur	Rajndpur,	1879-80	1060	6.2	11.1	82.4	1.08	858	4.8	95.7	3.0	..	..	51.7	54.7	1.3	..	..	44.0	45.8	..	..	33	33	..	33	33	0.77	2.24	3.01	..			
481				"	"	Burhanpur,	80-81	1060	6.4	11.2	82.4	6.0	863.65	4.6	95.4	3.8	..	..	47.6	51.4	0.8	..	..	47.8	48.6	..	..	61	61	..	61	61	0.51	0.80	1.31	..	
482				"	"	"	"	80-81	358	11.1	17.2	71.1	2.8	258.65	1.3	98.7	1.3	..	..	64.4	65.7	..	..	..	34.3	34.3	..	..	3	3	..	6	6	0.54	..	0.54	..
483				"	"	"	Lohah,	..	..	..	..	72.9	10.85	271.94	0.4	99.6	0.4	..	..	61.2	61.6	..	..	..	38.4	38.4	..	..	1	1	..	2	2	0.5	..	0.5	..
484	Mondwari	Kiroor	Nekpur	Nekpur,	79-80	851.0	30.5	16.2	53.3	103.5	558.65	20.6	79.4	5.0	..	0.5	51.0	56.5	7.5	..	7.6	28.4	43.5	8	12	..	..	..	..	..	..	..	..	..	..		
485				"	"	"	80-81	851.0	20.0	15.6	55.4	23.10	685.4	9.5	90.5	4.0	..	0.2	50.0	54.2	5.3	..	..	40.5	45.8	8	10	..	..	..	..	..	..	..	..	..	
486	Mondwari	Nawabganj	Purampur	Nawabganj,	79-80	888.35	9.4	11.6	79.0	103.7	804.75	21.2	78.8	5.13	..	0.7	46.8	53.0	7.9	0.3	7.8	32.0	48.0	..	..	35	35	..	35	35	1.20	1.80	3.00	..			
487				"	"	"	80-81	888.35	8.8	10.6	80.7	121.7	878.2	6.6	94.5	4.9	..	2.0	56.7	61.8	0.3	0.1	..	37.8	38.2	..	..	24	24	..	24	24	1.70	0.12	1.82	..	
488				"	"	"	"	80-81	1508.0	9.5	15.0	71.5	163.15	1290.9	3.1	96.9	2.9	..	..	42.9	45.8	0.2	..	..	54.0	54.2	..	..	38	38	..	70	70	0.52	0.05	0.57	..
489				"	"	"	Dhurnaganjpur,	79-80	267.2	8.8	23.1	68.1	31.02	213.37	31.6	65.4	4.9	..	0.3	30.6	35.5	21.0	..	8.7	34.8	64.5	1	..	8	9	..	9	9	1.13	5.0	6.13	..
490	Mondwari	Shahjahanpur	Shahjahanpur	"	80-91	267.2	8.9	21.6	69.6	29.75	215.60	8.9	91.1	8.2	..	..	48.3	56.8	..	..	0.4	42.8	43.2	1	..	2	2	..	2	2	5.98	..	5.98	..	..		
491				"	"	"	79-80	3088.0	48.1	11.1	40.5	..	1249.8	62.9	37.1	31.7	..	0.6	18.5	50.8	13.4	..	17.2	18.6	49.2	1 p 27	..	1 p 50	104	77	87	164	3.06	1.01	4.07	..	
492	Mondwari	Jalalabad	Jalalabad	"	80-81	3100.5	18.3	10.2	11.5	378.7	1667.0	66.1	33.9	23.5	..	3.5	20.0	47.0	13.1	..	26.0	13.9	53.0	1 p 27	..	1 p 50	288	77	211	288	1.40	0.8	2.2	..			
493				"	"	"	79-80	716.0	27.3	17.7	57.0	16.0	653.3	28.5	71.5	1.8	..	..	38.7	40.5	12.4	..	14.8	32.8	59.5	..	..	1 p 106	106	..	..	..	..	..	..	..	
494	Mondwari	Jalalabad	Jalalabad	"	80-81	716.0	25.7	15.9	58.0	56.75	474.45	41.1	58.9	3.4	..	..	38.4	41.8	24.5	..	13.2	20.5	58.2	..	..	1 p 106	106	..	..	..	..	..	..	..			
495				"	"	"	79-80	716.0	25.7	15.9	58.0	56.75	474.45	41.1	58.9	3.4	..	..	38.4	41.8	24.5	..	13.2	20.5	58.2	..	..	1 p 106	106	..	..	..	..	..	..	..	

Native State  
Wells examined are in  
Mukranpur

Nearly all sugarcane  
" " "

W S has fallen 5' to  
6' (1882-83)

W S has fallen 3'  
(1882-83)

W S rises 6' with  
Ranganga floods.

TABLE A—*Observation and Experiment—(Continued)*

[illegible]

TABLE A — *Observation and Experiment—(Continued).*

EXPERIMENTAL.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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Khayf 1881-82														Rabi 1881-82																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
Serial Number	Class	Pura of cattle to each lift.	Lift		Depth to Wells			Soil	Khayf 1881-82				Rabi 1881-82				Khayf 1881-82				Rabi 1881-82				Khayf 1881-82				Rabi 1881-82																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
			Number	Content in cubic feet.	Morning	Evening	Mean.		Crop	Waterings required.	Area	Total area reduced to one watering.	No. of days to area.	Crop	Waterings required.	Area.	Total area reduced to one watering.	No. of days to area.	Crop	Waterings given.	Area	Working days to date.	Per lift.	Per pair	Crop	Waterings given.	Area	Working days to date.	Per lift.	Per pair																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									



TABLE A.—*Observation and Experiment—(Continued).*

EXPENDITURE																											
Work										Cost.					Remarks												
Serial Number	Duration of work,		No. of lifts.	Cable feet lifted,		H P		Length of watercourse.	Area irrigated			Depth		Days to an acre			Per Acre										
	minutes	seconds		Per pair of cattle,	Per lift, per hour	Total per well	Per bullock,		Total per well	Crop	Watering	Interval	Area in square feet.	On area.	Of damp	Per pair of cattle	Per lift.	Per well.	Day per pair		Interest at 5 p c	Wells, sur, &c	Total	Lifting	Total		
476	19	15	711	90	190	200	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
477	217	214	600	10	210	200	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
478	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
479	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
480	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
481	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
482	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
483	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
484	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
485	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
486	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
487	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
488	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
489	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
490	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
491	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
492	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
493	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
494	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
495	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
496	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
497	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
498	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
499	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
500	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
501	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
502	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
503	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
504	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
505	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
506	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
507	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
508	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
509	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
510	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
511	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
512	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
513	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
514	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
515	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
516	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
517	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
518	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
519	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
520	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
521	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	
522	208	22	600	112	220	210	181	312	800	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	

TABLE A — Observation and Experiment—(Continued)

STATISTICAL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
Locality		Percentage of Total Cultivated Area.												Irrigation Wells										Lofta		Average area per lift in acres		Remarks.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
		Cultivated Area						Kharif.						Rabi																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
		Area in Acres		Percentage of actual area cultivated		Double cropped area in acres		Total area actually cul- tivated in the year		Wet.		Dry		Total		Wet.		Dry		Total																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
Year	Area in Acres		Percentage of actual area cultivated		Double cropped area in acres		Total area actually cul- tivated in the year		Wet.		Dry		Total		Wet.		Dry		Total		Lame masonry		Dry bricks.		Kucha.		Total.		Leather bucket.		Barthen pots.		Total.		Usual labor for lifting buckets.		Kharif		Rabi.		Total.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						

TABLE A—Observation and Experiment—(Continued).

## DESCRIPTIVE

Date		Class.	Cost						Supply.	Quality	Substratum	Cultivators on well		Labor and cost per day in annas										
Serial Number	Day		Month	Year	Construction.	Plantings.	Total.	Renewal.				Talis.	Yearly repairs.	Total.	Number	Caste	Men, home.	Do, hired.	Rate, per day.	Cattle.	Cost for men.	Do for cattle.	Total cost, per day	
527	38	10	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	
534	•	Kucha unlined, very old,	•	1/	•	1/-	•	•	1/-	•	1/-	Spring,	Sweet,	Clay,	•	2	1	5	15	•	•	•	•	-1/6
520	•	" "	202	1/-	•	1/	•	•	1/	•	1/	"	"	"	•	2	1	20	3	3	•	•	6/-	
528	16	Kucha lined with wood,	853	•	•	•	•	•	•	•	•	"	"	"	1	Herisman,	•	•	•	•	•	•	•	
533	16	" "	850	•	•	•	•	•	•	•	•	"	"	"	1	Kach,	3	•	•	2	3	•	-5/-	
535	20	Masonry,	•	150/-	3/-	153/-	•	5/-	1/-	1/-	6/-	"	"	43',	1	Pathan,	•	3	15	2	40	30	-7/6	
537	•	Kucha,	•	6/	21/-	10/	•	4/-	2/-	2/-	10/	"	"	"	2	Lodha,	•	•	•	4	2	6	-8/-	
539	•	"	•	6/-	4/-	10/	•	4/-	2/-	6/-	6/-	"	"	"	•	Musalman,	•	•	•	•	•	•	•	
540	•	"	•	6/-	4/-	10/-	•	•	4/-	2/-	6/-	Percolation,	"	"	•	Kach,	•	4	2	6	6	6	8/-	
542	21	"	•	2/-	1/-	3/-	1/-	1/-	1/	•	2/	"	"	Sand,	•	Mahajan,	•	2	2	30	•	•	5/-	
545	•	"	•	2/-	1/-	3/-	1/-	1/-	1/-	•	2/	"	"	"	•	Kach,	•	•	3	•	•	•	3/-	
549	•	"	•	2/-	1/-	3/-	1/-	1/-	1/-	•	2/-	"	"	"	•	Lodha,	•	3	•	•	•	•	-2/6	
552	22	Kucha unlined, 10 years' old,	•	5/-	3/-	8/	•	•	4/-	1/-	5/-	Spring,	"	Clay,	•	Brahmin,	3	•	3	2	4	5	-6/6	
555	23	Masonry, old,	•	150/-	3/	153/-	•	•	4/-	1/-	5/	"	"	"	•	Channar,	8	•	7	•	•	•	-7/-	
550	23	Kucha lined,	•	3/-	2/	5/-	3/-	4/	4/	•	7/-	"	"	"	•	Kach,	•	4	2	6	6	6	-8/-	
553	23	" "	•	3/-	2/-	5/	3/-	4/	4/	•	7/-	"	"	"	•	"	•	7	•	•	•	•	-7/-	
550	•	" "	•	3/	2/-	5/-	3/-	4/-	4/-	•	7/	"	"	"	3	"	•	4	•	•	•	•	-1/-	
558	23	Masonry, old,	•	150/-	3/-	153/-	•	•	4/-	1/	5/-	"	"	"	7	Thakurs	•	10	14	•	•	•	14/-	
572	31	Dry brick,	182	27/-	3/	30/-	•	•	5/	1/-	6/	Percolation,	"	Sand,	1	Pathan,	•	1	2	•	•	•	-10/-	

TABLE A—*Observation and Experiment—(Continued)*

EXPERIMENTAL

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Kharif 1881-82												Rabi 1881-82																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
Serial Number	Run	Class	Pairs of cattle to each lift	Lift		Depth to Wells		Soil	Kharif 1881-82					Rabi 1881-82					Kharif 1881-82					Rabi 1881-82																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
				Number	Content in cubic feet	Morning	Evening		Mean	Crop	Waterings required	Area	Total area reduced to one watering	No of days to area	Crop	Waterings given	Area	Working days to date	Per lift	Per pair	Crop	Waterings given	Area	Working days to date	Per lift	Per pair																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		

TABLE A.—*Observation and Experiment—(Continued)*

EXPERIMENTAL

WORK.

COST.

Serial Number	Duration of work minutes.		Cubic feet lifted.			H. P.		Length of watercourse	Area Irrigated				Depth		Days to an acre				Annual.			Per Acre.			Remarks.
									Crop.	Watering	Interval	Area in square feet.			On area.	Of damp	Per pair of cattle.	Per lift.							
	100	101	102	103	101	102	103	104					105	106					107	108	109	110	111	112	
5251	400	2,267	..	09	005	785	314	150	Garden, ..	..	..	..	7,500	..12	70	..	11 5	11 5	..	0 1	20	21	..	..	2 wells together.
5258	527	384	115	115	1,014	1,507	826	270	{ Tobacco, ..	12 12 days,	..	..	7,550	..13	75	50	5 6	5 6	..	..	..	..	..	..	Area double cropped.
5257	530	450	138	138	1,181	2 005	1,110	160	Tobacco, ..	10 12 days,	..	..	8,105	..11	70	53	5 3	5 3	..	..	..	..	..	..	" "
5255	..	..	..	..	..	..	..	..	Wheat, ..	1	..	..	1,720	..	..	25	25	25	..	5 1	60	11 1	..	..	Water short.
5257	..	..	..	..	..	..	..	..	" ..	1	..	..	7,000	..	..	11 1	11 4	5 7	..	5 5	100	10 5	..	..	
5259	..	..	..	..	..	..	..	800	{ ..	..	..	..	..	..	..	14	14	14	..	10	120	13 0	..	..	
5260	..	..	..	..	..	..	..	420	" ..	1	..	..	0,000	..	..	..	..	..	..	..	..	..	..	..	
5212	..	..	..	..	..	..	..	{ 500	" ..	1	..	..	1,400	..	..	..	30	30	..	0 2	20	22	..	..	
5210	..	..	..	..	..	..	..	{ 150	" ..	1	..	..	3,110	..	..	..	13	13	..	..	..	..	..	..	
5247	480	..	..	..	..	..	..	300	Opium, ..	1	..	..	2,250	..	..	..	19	19	..	0 2	20	22	..	..	
5210	..	..	..	..	..	..	..	200	{ Wheat, ..	1	..	..	1,702	..	..	..	25	25	..	0 2	20	22	..	..	
5252	600	531	80	118	1,197	405	312	400	{ Opium, ..	1	..	..	5,000	..239	..	130	8 7	8 7	..	0 1	50	54	..	..	
5255	660	1,202	..	108	1,815	472	311	1,700	" ..	1	..	..	10,000	..115	..	..	27	27	..	70	50	120	..	..	
5250	..	..	..	..	..	..	..	..	" ..	1	..	..	10,000	..	..	54	27	2 7	..	0 3	70	73	..	..	
5263	..	..	..	..	..	..	..	..	Barley, ..	1	..	..	0,408	..	..	..	10	4 6	..	0 0	70	73	..	..	
5260	..	..	..	..	..	..	..	..	{ Wheat, ..	1	..	..	4,850	..	..	..	9	9	..	0 3	70	73	..	..	
5268	750	1,020	..	307	4,908	440	330	700	Opium, ..	1	..	..	24,000	..211	..	..	1 81	1 81	..	7 6	50	12 6	..	..	
5272	..	..	..	..	..	..	..	380	Wheat, ..	1	..	..	4,754	..	..	9	9	9	..	1 5	60	7 5	..	..	

TABLE A—Observation and Experiment—(Continued).

## STATISTICAL.

Locality			Area in Acres				Cultivated Area				Percentage of Total Cultivated Area.										Irrigation Wells.				Lifts.			Average area per lift, in acres			Remarks																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
1	2	3	4	5	6	7	Percentage uncultivated		8	9	10	11	12	Kharif				Rabi				25	26	27	28	29	30	31	32	33		34	35																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
							Actual area in acres.	Waste.						Culturable.	Wet	Dry	Wells	Cannals.	Other sources.	Wet	Wells													Cannals.	Other sources.	Dry	Total																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
Serial Number	Province	District	Fergana	Village	Year																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																

TABLE A — Observation and Experiment—(Continued)

## DESCRIPTIVE

Serial Number	Date	Class	Cost					Supply	Quality	Substratum	Cultivators on well		Labor and cost per day in annas.								
			Construction.	Pittings.	Total.	Renewal.	Latia.				Yearly repairs	Total.	Number	Caste.	Men, home.	Do hired.	Rate, per day	Cattle.	Cost for men	Do. for cattle	Total cost, per day
37 3359 10	Year	42	10	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
571 3 182	..	Dry brick,	27/-	3/-	30/-	..	5/-	1/-	0/-	Spring, ..	Sweet,	Clay,	..	1 Kachi,	4	..	..	4	3	6	-89/-
578 4 182	..	"	27/-	3/-	30/-	..	5/-	1/-	0/-	"	"	"	..	3 Ahirs,	2	1	15	4	25	6	-86
581 4 182	..	"	27/-	3/-	30/-	..	5/-	1/-	0/-	"	"	"	..	7 " Brahmin,	8	..	..	..	7	..	-17/-
584 4 182	..	Kucha,	6/-	3/-	9/-	2/-	5/-	1/-	8/-	"	"	"	..	1 " "	3	..	..	1	3	6	-18/-
585 4 182	..	"	6/-	3/-	9/-	2/-	5/-	1/-	8/-	"	"	"	..	1 " "	3	..	..	1	3	15	-10/-
588 5 182	..	Masonry,	150/-	8/-	158/-	..	4/-	1/-	5/-	"	"	"	..	1 Musalman,	2	1	15	6	35	9	-112/6
590 ..	..	Dry brick,	20/-	3/-	..	2/-	4/-	2/-	12/-	"	"	"	..	1 " "	9	15	..	13	5	..	-13/6
591 6 182	..	Kucha,	5/-	5/-	31/-	1/-	1/-	..	2/-	Percolation,	"	"	..	1 Kachi,	3	35	4	15	6	..	-10/6
598 6 182	..	" lined,	1/-	0 5	15	1/-	1/-	..	2/-	"	"	Sand,	..	1 " "	2	..	..	1	..	..	-11/-
599 ..	..	"	2/-	1/-	3/-	2/-	1/-	..	4/-	"	"	"	..	1 Kachi,	3	..	..	2	..	..	-12/-
598 ..	..	"	2/-	1/-	3/-	2/-	1/-	..	4/-	"	"	"	..	1 Brahmin,	3	..	..	2	..	..	-12/-
600 ..	..	"	7/-	3/-	10/-	7/-	1/-	..	14/-	"	"	"	..	3 Kurmis,	3	..	..	2	..	..	-12/-
600 ..	..	"	7/-	3/-	10/-	7/-	1/-	..	14/-	"	"	"	..	3 Kurmis,	3	..	..	2	..	..	-12/-
602 7 182	..	"	2/-	1/-	3/-	2/-	5	..	8/-	"	"	"	..	2 Kachis,	3	..	..	2	..	..	-12/-
605 ..	..	1 "	1/-	0 5	15	1/-	0 5	..	15	"	"	"	..	1 " "	2	..	..	1	1	..	-11/-
608 8	..	3 "	2/-	2/-	4/-	2/-	2/-	..	4/-	"	"	"	..	2 Brahmins, Lohars,	2	..	..	1	1	..	-11/-

TABLE A — *Observation and Experiment—(Continued).*

EXPERIMENTAL.

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Kharif 1881-82																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
Serial Number	Run.	Lift			Depth to Wells			Soil	Rabi 1881-82						Kharif 1881-82						Rabi 1881-82.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
		Pairs of cattle to each lift.	Number	Content in cubic feet.	Morning	Evening	Mean.		Crop.	Waterings required	Area.	Total area reduced to one watering	No. of days to area.	Crop.	Waterings given.	Area.	Working days to date.	Per lift.	Per pair	Duty																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
70	71							72													73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
574	Lagor,	..	2	1	225	30	40	35	Matyar,	69	..	8	1 06	8 18	40	..	3	6	0 46	2 25	..	Wheat, Opium, Potatoes, Wheat, Opium,	75	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..



TABLE A — Observation and Experiment—(Continued)

EXPERIMENTAL																							
WORK										COST													
Serial Number	Duration of work minutes	No of lifts	Cubic feet lifted			H P		Length of watercourse	Area Irrigated				Depth		Days to an acre			Annual			Per Acre		Remarks.
			Per pair of cattle, per hour	Per lift, per hour	Total per well	Per bullock.	Total per well		Crop	Watering	Interval	Area in square feet.	On area.	Of damp	Per pair of cattle	Per lift.	Per well	Interest at 3 p c.	Repairs, &c	Total	Per acre irrigated	Laying.	
574	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
578	540	206	68	126	1,136	584	315	1,120	Wheat, Opium, Potatoes,	1 30 days 2 15 days, 8 10 days,	9,278	..	..	94	47	47	15	60	75	113	114	115	Supply short.
581	540	881	..	116	1,321	Perman 168	264	670	Peas,	2 ..	13,500	10	..	..	32	32	15	60	73	..	..	..	Supply short.
584	570	501	55	110	1,037	470	265	580	Wheat,	2 ..	6,250	17	..	140	70	70	05	80	85	..	..	..	Supply short.
586	570	488	33	50	468	771	189	420	"	1 ..	3,850	1475	..	165	11	11	05	80	85	..	..	..	Supply short.
588	520	501	50	150	1,298	331	207	510	"	2 30 days,	8,423	154	..	15	5	5	76	50	126	..	..	..	Supply short.
590	550	653	..	160	1,470	477	262	500	"	1 ..	5,866	25	..	50	74	74	16	120	136	..	..	..	Supply short.
591	..	..	..	..	..	..	..	..	Garden Wheat,	1 ..	1,610	..	..	..	25	25	01	20	21	..	..	..	Supply short.
593	..	..	..	..	..	..	..	..	"	1 ..	4,420	..	..	..	10	10	..	..	..	..	..	..	Supply short.
596	..	..	..	..	..	..	..	..	"	1 ..	2,250	..	..	..	20	20	02	40	42	..	..	..	Supply short.
598	..	..	..	..	..	..	..	..	"	1 ..	1,376	..	..	..	31	31	02	40	42	..	..	..	Supply short.
600	..	..	..	..	..	..	..	..	"	1 ..	2,000	..	..	..	21	21	05	110	115	..	..	..	Supply short.
602	390	1,242	..	83	541	Perman 400	150	190	Opium,	1 ..	4,055	235	..	..	20	20	02	30	32	..	..	..	Supply short.
605	380	1,076	..	65	424	Perman 308	114	150	Opium,	1 ..	3,077	178	..	..	14	14	01	15	16	..	..	..	Supply short.
608	630	1,721	..	51	540	238	153	120	Wheat	1 ..	2,500	20	..	..	17	17	01	15	16	..	..	..	Supply short.
609	600	1,267	..	47	498	219	138	500	Opium,	1 ..	4,100	12	..	..	10	10	02	40	42	..	..	..	Supply short.

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TABLE B.

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TABLE B—Showing the Yearly Area in Acres commanded by Wells in 20 Districts of the North-Western

District.	Number.	Depth to water surface.	No of lifts.	No of cattle or men lifting	Class	RABI			KHARIF			RABI					
						Duty per			Duty per			Wheat.	Wheat & Barley	Wheat & Gram.	Barley.	Barley & Gram.	Barley & Peas
						Well.	Lift.	Pair	Well	Lift.	Pair						
Cawnpore, ..	533	52	1	2	Lagor,	3 40	3 40	3 40	..	..	..	1 50	..	..	..	..	..
"	528	48	1	2	"	4 60	4 60	4 60	..	..	..	4	..	..	..	..	..
"	2	42	2	5	"	3 50	1 75	1 40	3 20	1 60	1 33	3 30	3 50	3	..	..	..
"	3	38	1	2	"	3 30	3 30	3 30	1 60	1 60	1 60	3	..	..	..	..	..
"	5	38	1	2	"	2 65	2 65	2 65	1 85	1 85	1 85	2 65	3	..	..	..	..
"	11	37	2	4	"	*1 00	0 50	0 50	..	.	..	1 00	3	..	..	..	..
"	37	37	2	4	"	3 50	1 75	1 75	..	..	..	3 50	3	..	..	..	..
"	9	36	2	4	"	3 77	1 88	1 88	..	..	..	2 45	2	..	..	..	..
"	13	35	3	6	"	8 58	2 86	2 86	..	..	..	2 23	3	..	..	..	3 45
"	8	32	2	4	"	3 85	1 92	1 92	..	..	..	3 85	4	..	..	..	2
"	16	29	1	3	"	3 10	3 10	2 06	..	..	..	3 10	2	..	..	..	..
"	21	20	2	4	"	6 10	3 05	3 05	2 0	1 0	1 0	6 10	3	..	..	..	..
"	22	20	2	4	"	6 10	3 05	3 05	2 0	1 0	1 0	6 10	3	..	..	..	..
"	20	16	1	2	"	1 50	1 50	1 50	..	.	..	1 50	2	..	..	..	..
Mean, ..	..	34	..	3 4	"	4 15	2 68	2 57	2 13	1 41	1 35	35 5	38 7	3	..	..	6 3
Hamirpur, ..	59	113	1	2	"	*0 15	0 15	0 15	.	.	..	..	..	..	..	..	..
"	60	111	2	4	"	*0 24	0 12	0 12	..	..	..	..	..	..	..	..	..
"	58	88	2	4	"	*0 32	0 16	0 16	..	..	..	..	..	..	..	..	..
"	61	57	1	2	"	..	..	..	2 27	2 27	2 27	..	..	..	..	..	..
"	45	45	3	6	"	2 Wells. 9 90	3 30	3 30	..	..	..	..	..	..	..	..	..
"	47	45	1	2	"	3 40	3 40	3 40	..	..	..	..	..	..	..	..	..
"	54	42	7	14	"	4 Wells 37 00	5 28	5 28	.	.	..	..	..	..	..	..	..
"	37	41	1	4	"	*0 90	0 90	0 45	1 73	1 73	0 86	..	..	..	..	..	..
"	36	38	1	2	"	2 10	2 10	2 10	..	.	.	..	..	..	..	..	..
"	50	38	6	12	"	4 Wells 14 00	2 33	2 33	..	..	..	..	..	..	..	..	..
"	40	37	1	2	"	1 30	1 30	1 30	.	..	..	..	..	..	..	..	..
"	26	36	2	4	"	4 56	2 28	2 28	.	..	..	..	..	..	..	..	..
"	38	36	1	2	"	3 50	3 50	3 50	.	..	.	..	..	..	..	..	..
"	24	35	1	4	"	2 00	2 00	1 00	..	..	..	..	..	..	..	..	..

\* The examples are omitted in the calculations for mean areas, &amp;c.

Provinces and Oudh, and the number of waterings required for each class of irrigated crop—1881-88.

RABI.											KHARIF					Remarks	
Safflower.	Safflower & Gram	Safflower & Carrots	Gram	Carrots	Peas	Oats.	Opium	Tobacco	Pointees.	Garlic.	Garden	Sugar	Cotton	Indian Corn	Millet.		Indigo.
..	..	..	..	..	..	..	..	1 70	1 70	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	..	12	12	..	..	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	..	1 00	1 00	..	1 60	..	..	..	..	..	Area
..	..	..	..	..	..	..	..	12	12	..	10	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	..	..	..	..	..	..	3 20	..	..	..	Area
..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	Waterings
..	..	..	..	..	..	..	..	..	..	..	..	..	1 60	..	..	..	Area
..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	Waterings
..	..	..	..	..	..	..	..	..	..	..	..	..	1 85	..	..	..	Area
..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	Waterings
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	1 32	..	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	6	..	..	..	..	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	2 90	..	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	6	..	..	..	..	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	..	..	..	..	..	..	2 00	..	..	..	Waterings
..	..	..	..	..	..	..	..	..	..	..	..	..	2	..	..	..	Area
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2 00	Waterings
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	Area
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	7 7	4 9	4 0	..	2 9	..	81 2	..	..	18 8	Per cent area
..	..	..	..	..	..	..	6	12	12	..	10	..	2	..	..	2	Mean waterings Area 65 60
..	..	..	..	..	..	..	0 15	..	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	10	..	..	..	..	..	..	..	..	..	Waterings.
..	..	..	..	..	..	..	0 24	..	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	10	..	..	..	..	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	0 32	..	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	7	..	..	..	..	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	..	..	..	..	..	2 27	..	..	..	..	Area
..	..	..	..	..	..	..	..	..	..	..	..	4	..	..	..	..	Waterings
..	..	..	..	..	..	..	..	9 9	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	..	5	..	..	..	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	..	3 4	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	..	5	..	..	..	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	..	37 0	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	..	7	..	..	..	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	..	..	..	..	0 9	1 73	..	..	..	..	Area
..	..	..	..	..	..	..	..	..	..	..	10	4	..	..	..	..	Waterings
..	..	..	..	..	..	..	2 1	..	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	10	..	..	..	..	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	..	14 0	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	..	7	..	..	..	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	..	..	..	..	1 3	..	..	..	..	..	Area
..	..	..	..	..	..	..	..	..	..	..	10	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	4 56	..	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	5	..	..	..	..	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	..	3 50	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	..	10	..	..	..	..	..	..	..	..	Waterings
..	..	..	..	..	..	..	2 0	..	..	..	..	..	..	..	..	..	Area
..	..	..	..	..	..	..	5	..	..	..	..	..	..	..	..	..	Waterings

TABLE B—Showing the Yearly Area in Acres commanded by Wells in 20 Districts of the North-Western

District	Number	Depth to water surface	No of lifts.	No of cattle or men lifting	Class	RABI			KHARIF			RABI					
						Duty per			Duty per			Wheat.	Wheat & Barley	Wheat & Gram	Barley	Barley & Gram	Barley & Peas.
						Well	Lift	Pair	Well	Lift	Pair						
Hamurpur—(Contd.)	32	27	2	4	Lagor,	4 00	2 00	2 00	..	..	..	..	..	..	..	..	..
"	31	22	1	4	"	2 83	2 83	1 11	..	..	..	..	..	..	..	..	..
"	29	22	1	2	"	2 60	2 60	2 60	2 60	2 60	2 60	..	..	..	..	..	..
"	27	21	1	2	"	*0 90	0 90	0 90	..	..	..	..	..	..	..	..	..
"	35	19	1	2	"	4 70	4 70	1 70	..	.	..	..	..	..	4 7	..	..
"	48	18	2	4	"	..	..	..	3 00	1 50	1 50	..	..	..	..	..	..
"	49	18	2	8	"	..	..	.	1 75	0 82	0 41	..	..	..	..	..	..
"	42	16	2	4	"	2 60	1 30	1 30	..	.	.	..	..	..	2 6	..	..
"	41	14	2	4	"	3 40	1 70	1 70	1 80	0 90	0 90	..	..	..	3 4	..	..
"	43	14	2	4	"	3 60	1 80	1 80	..	..	..	..	3 6	..	5	..	..
"	34	12	1	2	"	2 00	2 00	2 00	..	..	..	..	..	..	2 0	..	..
Mean, ..	Kharif, 28	.	4	}	"	4 32	2 61	2 50	2 19	1 64	1 42	..	3 1	3	12 0	6	..
	Rabi, 33	..	3														
Farakhabad, ..	67	66	7	14	"	6 Wells 35 90	5 13	5 13	..	..	..	5 60	..	..	30 30	1	..
"	63	58	2	4	"	8 50	4 25	4 25	..	..	..	1 23	..	..	7 23	2	..
"	90	58	1	2	"	3 26	3 26	3 26	1 63	1 63	1 63	..	..	..	..	..	..
"	66	57	1	2	"	2 11	2 11	2 11	..	.	..	..	2 11	..	..	..	..
"	88	56	1	2	"	3 46	3 46	3 46	1 73	1 73	1 73	..	..	..	..	..	..
"	72	47	1	2	"	3 92	3 92	3 92	.	.	..	..	..	..	2 66	2	.
"	69	46	2	5	"	3 Wells 7 73	3 86	3 09	..	..	..	4 26	..	..	1 43	2	..
"	92	36	1	2	"	2 58	2 58	2 58	1 29	1 29	1 29	..	..	..	..	..	..
"	74	35	1	2	"	3 15	3 15	3 15	..	..	..	0 66	0 86	..	1 26	2	..
"	84	35	1	2	"	1 20	1 20	1 20	..	.	..	0 90	4	..	..	..	..
"	94	35	1	2	"	2 34	2 34	2 34	1 17	1 17	1 17	..	..	..	..	..	..
"	78	32	1	2	"	2 69	2 69	2 69	.	..	.	1 09	1 60	..	..	..	..
"	80	32	1	2	"	3 07	3 07	3 07	.	.	..	1 26	0 57	..	0 94	2	..
"	87	16	1	1	Dhenkhi,	0 60	0 60	1 20	..	..	..	..	..	..	..	..	..
"	86	15	1	1	"	0 60	0 60	1 20	..	..	..	..	..	..	..	..	..
Mean, ..	Lagor, K 46	.	2	}	Lagor,	4 21	3 15	3 10	1 45	1 45	1 45	18 7	6 4	3	53 7	2	..
	R 51	..	2														
"	Dhenkhi, 16	..	1	Dhenkhi,	0 60	0 60	1 20	.	..	.	..	..	..	..	..	..	..

\* These examples are omitted in the calculations for mean areas, &amp;c.



TABLE B—Showing the Yearly Area in Acres commanded by Wells in 20 Districts of the North-Western

District	Number	Depth to water surface,	No of lifts	No of cattle or men lifting	Class.	RABI			KHARIF			RABI					
						Duty per			Duty per			Wheat	Wheat & Barley	Wheat & Gram	Barley	Barley & Gram.	Barley & Peas.
						Well.	Lift.	Pair	Well	Lift.	Pair						
Etah—(Contd)	192	19	2	4	Lagor,	6 40	3 20	3 20	.	.	.	1 30			4 00		
"	195	18	1	4	Kih,	*1 60	1 60	0 80				4	..	...	3		
"	178	14	3	6	Lagor,	2 Wells 4 70	1 57	1 57	1 70	0 57	.	2 70			2 00		
"	180	12	2	4	"	6 86	3 43	3 43			..	4	..		3		
"	183	12	2	4	"	6 90	3 45	3 45			..	6 00	1 26		0 66		
Mean,	..	16	..	4	"	5 92	3 20	2 50	1 70	0 57	0 57	4	3	..	3	..	...
Aligarh,	255	45	2	4	Kih,	7 98	3 99	3 99				3 52			3 46		
"	251	39	1	4	"	5 62	5 62	2 81	..	...	...	4	..	...	3	..	
"	248	38	1	2	"	8 80	8 80	8 80	..	...		3 63			1 43		
"	279	35	1	4	"	7 40	7 40	3 20	.			4			3		
"	275	33	2	4	"	16 73	8 36	8 36		..		3 90			4 90		
"	259	29	7	28	"	42 16	6 02	3 01				5	...		4	..	
"	242	28	1	4	"	6 34	6 34	3 17	.		..	2 23			0 23		
"	239	27	1	2	"	1 95	1 95	1 95	..			4			3	..	
"	283	27	1	4	"	8 04	8 04	4 02				5 20					11 30
"	268	23	4	8	"	22 99	5 75	5 75				3					3
"	225	20	3	..	"	22 86	7 27	.				27 20	2 65		1 03		9 94
"	229	20	2	6	"	17 14	8 57	5 71	3 17	1 58	1 06	3	3		2	..	2
"	234	19	3	6	"	14 79	4 93	4 93				2 71					
"	207	18	1	6	"	9 91	9 91	3 30	3 57	3 57	1 19	5					
"	221	17	1	4	"	16 37	16 37	8 09				0 83			1 12		
"	211	16	2	6	"	9 05	4 52	3 02	2 43	1 22	0 81	5	...		4	..	
"	217	16	2	12	"	22 45	11 22	3 74		..		2 30			2 14		3 60
"	203	14	1	4	"	8 52	8 52	4 26				4	..		8		3
"	200	11	2	8	"	9 43	4 71	2 36				9 90	3 40		4 50		
Mean,	Kharif, Rabi,	18 24 7		6	"	12 92	7 28	4 50	3 02	2 12	1 02	3	3		2		
Muzra,	307	67	2	8	"	13 52	6 76	3 38				13 57			7 43		
"	300	62	2	4	Lagor,	7 01	3 50	3 50	.			10 90			8 75		

\* These examples are omitted in the calculations for mean areas, &amp;c.

Provinces and Oudh, and the number of waterings required for each class of irrigated crop—1881-83—(Continued)

RABLI											KHARIF					Remarks.	
Safflower	Safflower & Gram	Safflower & Carrots	Gram	Carrots	Peas	Oats	Opium	Tobacco,	Potatoes	Garlic	Garden	Sugar	Cotton	Indian Corn	Millet		Indigo
.	.	.	.	1 10 8	.	.	.	.	.	.	.	.	.	.	.	.	Area
..	.	.	.	.	..	.	.	.	.	.	.	.	.	.	.	.	Waterings
.	.	.	.	.	.	..	0 20 10	.	.	.	.	1 70 3	.	.	..	..	Area
.	.	.	.	0 54 10	.	..	1 00 8	.	.	.	.	.	.	..	..	..	Waterings
.	.	.	.	4 0 9	.	0 5 6	3 0 9	.	.	.	.	100 0 3	.	..	.	.	Area
..	.	.	.	.	..	.	.	.	.	.	.	.	.	.	.	.	Waterings
..	.	.	.	.	.	.	.	.	.	.	1 00 4	.	..	.	.	.	Per cent area
.	.	0 66 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Mean waterings. Area 43 18
.	.	.	.	4 94 5	.	.	.	.	.	.	.	.	.	.	.	.	Area
.	0 23 1	.	.	...	.	.	.	.	.	.	.	.	.	.	...	...	Waterings.
.	.	1 34 5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Area
..	.	0 83 3	.	.	.	.	.	0 80 6	1 10 4	1 00 10	.	.	.	.	.	.	Waterings
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Area
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Waterings
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	..	Area
.	.	1 26 5	.	.	.	.	.	3 03 10	.	.	0 90 10	.	.	.	.	.	Waterings
.	.	.	.	.	1 86 2	.	.	.	.	.	.	.	.	.	.	.	Area
0 60 3	.	.	.	.	1 51 2	.	.	.	.	.	.	.	3 17 2	.	.	.	Waterings
.	.	.	1 14 1	.	.	.	.	1 29 10	.	.	.	.	.	.	.	.	Area
.	.	.	.	.	.	.	.	0 30 10	0 57 10	.	.	.	3 57 2	.	..	.	Waterings
.	.	.	.	.	.	0 12 6	.	.	.	.	.	.	.	.	.	.	Area
.	.	.	.	.	.	.	0 20 10	1 28 10	.	.	.	.	2 43 2	.	..	.	Waterings
..	.	.	.	.	.	.	.	.	.	.	.	.	.	.	..	.	Area
.	.	.	2 80 1	.	.	.	.	.	.	.	.	.	.	.	.	.	Waterings
.	.	.	2 11 1	.	.	.	.	.	.	.	.	.	.	.	.	.	Area
.	.	.	.	.	.	.	...	.	.	.	.	.	.	.	.	.	Waterings
0 4 3	0 1 1	1 6 4	2 0 1	2 0 5	1 4 2	0 05 6	0 2 10	2 7 10	0 6 4	0 55 10	1 00 7	100 0 2	.	.	.	.	Per cent area
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	Mean waterings Area 267 80
.	.	0 57 5	.	..	.	.	.	.	.	.	.	.	.	..	.	.	Area
.	.	.	.	..	.	.	.	.	..	.	.	.	.	.	.	.	Waterings



TABLE B—Showing the Yearly Area in Acres commanded by Wells in 20 Districts of the North-Western

District	Number	Depth to water surface	No of lifts	No of cattle or men lifting	Class	RABI			KHARIF			RABI					
						Duty per			Duty per			Wheat	Wheat & Barley	Wheat & Gram	Barley	Barley & Gram	Barley & Peas
						Well	Lift	Pair	Well	Lift	Pair						
Muttra—(Contd),	319	59	2	4	Kuh,	9 17	4 58	4 58				4 72 5			2 73 3		1 06 3
"	325	59	2	4	"	10 49	5 24	5 24				0 71 3			0 32 2		9 46 2
"	312	58	1	2	"	4 23	4 23	4 23				4 20 4					
"	315	58	1	4	"	*1 75	1 75	0 87				0 63 5	1 10 4				
"	287	51	1	2	"	5 30	5 30	5 30				2 56 5		1 37 5	1 37 4		
"	291	49	1	2	"	6 59	6 59	6 59								6 59 3	
"	294	48	1	2	"	3 24	3 24	3 24				1 70 5			1 54 4		
"	296	46	2	4	"	17 62	8 81	8 81				12 07 5			3 00 4		
"	304	16	1	2	"	5 45	5 45	5 45				1 38 3			4 07 2		
Mean,		51		3 4	"	8 40	5 58	5 20				48 3 5	2 15 4	1 6 5	23 0 3	7 8 3	12 6 2
Bulandshahr,	334	39	1	2	"	3 11	3 11	3 11					1 347 2				
"	340	34	3	10	"	10 44	3 45	2 09	2 10	0 70	0 42	6 17 6			0 48 5		
"	329	30	2	8	"	2 Wells. 13 02	6 51	3 26				3 56 4	3 65 3	2 25 3			3 56 2
"	374	30	2	8	"	28 62	14 31	7 15				10 60 4	1 78 4	11 40 3			
"	359	27	2	8	"	19 36	9 68	4 84				5 53 4	1 625 4	2 65 3	0 22 3		1 56 3
"	369	27	1	4	"	3 92	3 92	1 96				2 09 4			0 06 3		
"	389	26	2	8	"	18 54	9 27	4 63				4 81 4					5 09 3
"	346	23	3	6	"	22 01	7 34	7 34	2 20	0 73	0 73	4 50 7			3 54 4		
"	381	18	1	4	"	6 69	6 69	3 35				2 56 4	2 12 4				
"	386	16	1	4	"	4 35	4 35	2 18				0 88 4					
"	400	16	1	4	"	8 11	8 11	4 05	1 12	1 12	0 51	4 12 4		0 96 4	0 13 3		2 70 3
"	394	15	1	4	"	11 85	11 85	5 93				5 38 4	0 88 4		1 57 3		3 36 3
"	353	14	1	4	"	9 02	9 02	4 51					0 65 4		2 30 3		3 17 3
Mean,	Kharif, Rabi,	24 24		5 7	"	11 36	7 50	4 18	1 81	0 85	0 55	24 6 4	13 1 4	4 6 3	12 9 3		12 8 3
Meerut,	434	27	2	8	"	11 20	5 60	2 80				7 22 3					
"	410	25	4	16	"	3 Wells. 23 27	5 82	2 91	2 60	0 65	0 33	15 00 4	3 80 3				1 12 3
"	430	25	3	12	"	26 05	8 68	4 34				14 43 4		9 00 4	2 62 3		
"	425	21	2	8	"	18 03	9 01	4 51	9 75	4 87	2 44	9 25 4					7 20 3

\* These examples are omitted in the calculations for mean areas, &amp;c.

Provinces and Oudh, and the number of waterings required for each class of irrigated crop—1881-83—(Continued).

RABI												KHARIF					Remarks.
Safflower	Safflower & Gram.	Safflower & Carrots.	Gram.	Carrots	Peas	Oats	Opium	Tobacco	Potatoes	Garlic	Garden	Sugar	Cotton.	Indian Corn.	Millet	Indigo.	
...	...	0 64 6	.	...	.	..	..	...	..	.	0 02 10						Area
...	...	...	.	...	.	.	.	...	.	.		...	.	..	...	..	Waterings
...	...	...	...	...	..	..	.	...	...	.	0 03 10	.	.	.	...	...	Area.
...	...	...	...	...	.	.	..	.	.	..	0 02 10	...	.	.	.	.	Waterings
...	...	...	...	...	.	.	..	.	.	..		...	.	.	.	.	Area.
...	...	...	...	.	.	...	...	.	..	...	..	...	.	.	.	.	Waterings.
...	...	...	...	...	..	.	.	.	.	.	..		..	.	..	..	Area.
...	...	...	...	...	..	.	.	.	.	.	..	.	..	.	..	..	Waterings
...	...	2 55 5	.	.	..	..	.	.	.	.		.	..	.	.	...	Area
...	...	...	...	...	.	.	..	.	.	.		.	..	.	.	...	Waterings.
...	...	...	...	...	.	.	..	.	.	.		..	..	.	.	...	Area
...	...	4 5 5	..	.	.	.	.	.	..	..	0 05 10		.	.	.	..	Per cent area
...	...	...	...	...	.	.	.	.	..	..			.	.	.	..	Mean waterings. Area 84 37
...	...	...	...	.	.	.	..	0 63 4	..	.	1 13 7			.	.	.	Area
...	...	...	...	...	0 42 6	..	.	.	.	.	3 37 10	0 79 4	1 31 1	.	.	.	Waterings
...	...	...	...	...	...	..	.	.	.	.		.	..	.	..	..	Area
...	...	...	1 34 2	.	0 50 2	.	.	3 00 8	.	.		.	...	.	..	.	Waterings.
...	...	...	2 56 2	..	0 56 2	.	.	3 00 8	.	.	1 65 7	.	...	.	.	.	Area
...	...	...	...	...	...	.	.	1 15 8	.	.	0 62 7	.	...	.	.	..	Waterings
...	...	...	...	...	...	.	.	...	.	.	3 03 7		...	.	..	..	Area
5 61 3	...	...	...	...	...	0 07 7	.	1 13 15	.	.	0 47 10	..	2 20 3	.	.	.	Waterings
12 00 3	...	...	...	...	1 70 2	..	.	...	..	.	0 31 7	.	.	.	.	..	Area
...	...	...	...	...	...	..	.	...	..	.	3 47 7	.	.	.	.	.	Waterings
...	...	...	...	...	...	.	.	...	.	.		2 80 4	1 12 1	.	.	.	Area
...	...	...	...	...	...	.	.	0 20 8	.	.			...	.	.	.	Waterings
...	...	...	...	...	...	.	.	...	.	.	0 66 6		...	..	..	.	Area
...	...	...	...	...	...	.	.	0 72 9	.	.	1 88 7		...	.	.	.	Waterings.
...	...	...	...	...	...	.	.	...	.	.			...	.	.	.	Area
11 0 3	...	...	2 3 2	.	1 8 2	0 3 6	.	6 1 9	..	.	10 5 8	43 7 4	56 3 2	.	.	.	Per cent area
...	...	...	...	...	...	...	.	...	2 70 10	..	1 28 10		.	.	.	.	Mean waterings Area 167 26
...	...	0 20 5	...	...	1 25 2	1 43 4	..	0 13 8	.	.	0 34 6	..	2 60 1	..	.	.	Area
...	...	...	...	...	...	.	.	...	..	.		.	...	.	..	.	Waterings
...	...	...	...	...	...	0 88 3	.	...	..	.		7 75 8	2 00 1	.	.	..	Area
...	...	...	0 70 1	.	...	...	.	...	..	.			...	.	.	.	Waterings

TABLE B—Showing the Yearly Area in Acres commanded by Wells in 20 Districts of the North-Western

District.	Number	Depth to water surface	No. of lifts	No. of cattle or men lifting	Class	RAIL			KHARIF			RAIL					
						Dry per			Dry per			Wheat	Wheat & Barley	Wheat & Gram	Barley	Barley & Gram	Barley & Peas
						Well	Lift	Pair	Well	Lift	Pair						
Meerut—(Contd), .	406	23	1	4	Kili,	3 89	3 89	1 95	.	...	..	0 66	3 00	.	...	...	0 23
"	419	20	2	8	"	14 34	7 17	3 59	...	..	..	11 30	4	...	0 47	...	2
"	439	19	1	4	"	10 42	10 42	5 21	...	.	..	5 20	4	...	3 91	...	..
Mean, ...	.	24	.	6	"	11 91	7 23	3 62	6 17	2 76	1 36	58 0	6 3	8 9	6 9	...	8 0
Muzaffarnagar, .	444	15	1	8	"	.	.	.	12 40	12 40	3 10	..	...	...	...	...	...
"	447	12	1	4	"	3 53	3 53	1 77	3 50	3 50	1 75	3 53	4	...	...	...	..
Mean, ..	Khanf Rabi,	13 12	...	6 4	"	3 53	3 53	1 77	7 95	7 95	2 42	100 0	4	...	...	...	.
Saharanpur, .	451	16	1	4	Lagor,	3 40	3 40	1 70	.	..	..	..	...	...	...	...	...
"	449	16	1	2	"	2 40	2 40	2 40	..	..	..	..	...	...	...	...	...
Mean,	.	17	.	3	"	2 90	2 90	2 05	..	.	..	..	...	...	...	...	...
Bijnor, ...	461	20	1	1	Dhenkhi,	1 25	1 25	2 50	..	...	.	..	...	...	...	...	.
"	463	20	1	1	"	0 25	0 25	0 50	.	...	.	..	...	...	...	...	...
"	453	17	1	2	Kili,	.	..	..	1 90	1 90	1 90	..	...	...	...	...	.
"	455	16	1	2	"	.	.	.	1 26	1 28	1 26	...	...	...	...	...	.
"	465	16	2	16	"	..	.	..	8 70	4 35	1 09	..	...	...	...	...	...
"	469	16	1	8	"	...	...	.	4 25	4 25	1 06	..	...	...	...	...	...
"	457	15	1	2	"	.	...	..	1 34	1 34	1 34	..	...	...	...	...	...
"	459	15	1	2	"	.	...	..	1 25	1 25	1 25	..	...	...	...	...	...
Mean, .	..	16	.	3	"	..	.	..	2 40	2 40	1 32	..	...	...	...	...	.
"	.	20	1	1	Dhenkhi,	0 75	0 75	1 50	..	.	..	..	...	...	...	...	...
Moradabad, .	478	20	1	4	Kili,	0 94	0 94	0 47	0 94	0 94	0 47	.	...	...	...	...	.
"	484	19	2	2	Dhenkhi,	...	...	.	1 00	0 50	1 00	..	...	...	...	...	.
"	471	18	2	8	Kili,	13 70	6 85	3 42	1 41	0 71	0 36	13 70	1	...	...	...	.



TABLE B—Showing the Yearly Area in Acres commanded by Wells in 20 Districts of the North-Western

District.	Number.	Depth to water surface.	No. of lifts	No of cattle or men lifting	Class.	RABI			KHARIF			RABI					
						Duty per			Duty per			Wheat.	Wheat & Barley	Wheat & Gram	Barley	Barley & Gram	Barley & Peas.
						Well	Lift.	Pair	Well	Lift.	Pair						
Moradabad—(Contd.)	476	18	1	2	Kali,	1 00	1 00	1 00	..	..	..	..	..	..	..	..	..
"	480	10	2	2	Dhenkhi,	..	..	..	0 90	0 45	0 90	..	..	..	..	..	..
Mean,	..	15	..	2	"	..	..	..	0 95	0 47	0 95	87 5	1	..	..	..	..
"	..	19	..	4	Kali,	3 91	2 93	1 63	1 17	0 82	0 42	..	..	..	..	..	..
Rampur State, ...	488	21	2	1	Rāti,	0 22	0 22	0 44	..	..	..	..	..	..	..	..	..
Bareilly,	490	38	3	6	Kali,	9 40	3 13	3 13	..	..	..	..	..	..	..	..	..
"	494	38	1	2	"	2 13	2 13	2 13	..	..	..	0 63	2	..	..	..	..
"	497	9	2	1	Rāti,	0 50	0 50	1 00	..	..	..	..	..	..	..	..	..
Mean,	..	38	..	2	Kali,	2 90	2 63	2 63	..	..	..	50	2	..	..	..	..
Pilibhit,	501	15	2	3	Dhenkhi,	..	..	..	2 80	1 40	1 86	..	..	..	..	..	..
Shahjahanpur, ..	517	33	1	2	Lagor,	2 30	2 30	2 30	..	..	..	..	..	..	..	..	..
"	514	32	1	2	"	2 28	2 28	2 28	..	..	..	..	..	..	0 56	2	..
"	505	30	1	6	Coohe,	4 50	4 50	1 50	2 44	2 44	0 81	4 50	1	..	..	..	..
"	508	25	1	6	"	..	..	..	7 56	7 56	2 52	13 3	1	..	..	..	..
"	522	24	2	1	Rāti,	1 16	1 16	2 32	..	..	..	..	..	..	..	..	..
"	526	24	4	2	"	2 32	1 16	2 32	..	..	..	..	..	..	..	..	..
"	520	13	1	1	Dhenkhi,	0 63	0 63	1 26	..	..	..	..	..	..	..	..	..
Mean,	..	33	..	2	Lagor,	2 29	2 29	2 29	..	..	..	67 2	1	..	2 1	2	..
"	..	37	..	6	Coohe,	4 50	4 50	1 50	5 00	5 00	1 66	..	..	..	..	..	..
Unao,	535	38	1	2	Lagor,	1 27	1 27	1 27	..	..	..	1 27	4	..	..	..	..
"	537	32	2	4	"	2 94	1 47	1 47	..	..	..	2 94	4	..	..	..	..
"	539	32	1	2	"	1 89	1 89	1 89	..	..	..	1 89	4	..	..	..	..
"	540	31	1	2	"	3 09	3 09	3 09	..	..	..	3 09	4	..	..	..	..
"	542	20	1	2	Coohe,	0 70	0 70	0 70	..	..	..	0 70	3	..	..	..	..

Provinces and Oudh, and the number of waterings required for each class of irrigated crop—1881-83—(Continued)

RABI												KHARIF					Remarks
Safflower.	Safflower & Gram	Safflower & Carrots	Gram	Carrots.	Peas	Oats	Opium	Tobacco	Potatoes	Garlic	Garden	Sugar	Cotton.	Indian Corn	Millet.	Indigo	
.	..	.	.	...	.	.	.	1 00 30	.	.	.	.	0 90 4	.	.	.	Area Waterings Area Waterings
.	.	.	.	...	..	.	.	12 5 30	.	..	..	80 0 4	.	20 0	.	.	Per cent area Mean watering Area 18 95
.	.	.	.	.	.	..	.	0 15 28 67 0 28	.	.	0 07 28 33 0 28	.	.	.	.	.	Area Area 0 22 Watering Rabi counted as 1 lift. Per cent area Mean waterings
.	..	.	..	.	.	.	.	9 40 20 1 50 20	.	.	0 50 10	.	.	.	.	.	Area Waterings Area Waterings Area Waterings
..	.	.	.	.	.	.	.	90 8 20	.	.	4 2 10	.	.	.	.	.	Per cent area Mean watering Area 12 03
.	.	.	.	.	.	.	.	2 30 20 1 72 20	.	.	.	2 80 2	.	.	.	.	Area Waterings Area 2 80
...	.	.	.	.	.	.	.	.	.	.	.	.	2 44 2 7 56 2	.	.	..	Area Waterings Area Waterings Area Waterings Area Waterings
.	.	..	..	.	.	.	.	.	.	.	1 16 20 2 32 20 0 63 20	.	.	.	.	.	Area Waterings Area Waterings Area Waterings
.	.	.	.	.	.	.	.	15 2 20	.	.	15 5 20	100 0 2	..	.	.	.	Per cent area Mean waterings Area 36 35
.	.	.	.	.	..	.	.	.	.	..	..	.	..	.	.	.	Area. Waterings Area Waterings Area Waterings Area Waterings
.	.	...	.	.	..	.	.	.	.	.	.	..	..	.	.	.	Area Waterings Area Waterings

TABLE B—Showing the Yearly Area in Acres commanded by Wells in 20 Districts of the North-Western

District.	Number	Depth to water surface	No of lifts	No of rattle or men lifting	Class	RAJL			KHARIF			RAJL					
						Duty per			Duty per			Wheat.	Wheat & Barley	Wheat & Grain	Barley	Barley & Grain	Barley & Peas
						Well	Lift	Pair	Well	Lift	Pair						
Unao—(Contd.),	545	20	1	2	Coolie,	1 33	1 33	1 33				0 28					
,	519	20	1	2	"	0 50	0 50	0 50				4	..				
Mean,		34		2	Lagor,	2 30	1 93	1 93				88 4	..				
"		20		2	Coolie,	0 84	0 84	0 84				4	.	.			
Lucknow,	572	35	1	2	Lagor,	2 50	2 50	2 50				2 50					
,	578	32	1	4	"	4 48	4 48	2 24	0 51	0 51	0 26	3	..				
"	574	35	1	4	"	3 41	3 41	1 71	1 06	1 06	0 53	3	.				
,	555	30	1	6	Coolie,	12 65	12 65	4 22				9 90			2 13		
"	563	25	1	7	"	8 00	8 00	2 29				2	.		2		
"	559	24	1	4	Lagor,	13 65	13 65	6 82				4 00			4 00		
"	566	24	1	4	Coolie,	*1 54	1 54	0 77				2	.		2		
,	552	22	1	3	Lagor,	3 76	3 76	2 50				7 15			1 30		
"	568	17	1	5	Coolie,	16 38	16 38	4 09				2			2		
Mean,		30		3 4	Lagor,	6 95	6 95	3 94	0 78	0 78	0 39	64 7			19 1		
"		24		7 0	Coolie,	12 34	12 34	3 53				3			2		
Hardoi,	590	30	1	7	"	7 00	7 00	2 00				7 00					
"	588	25	1	6	Lagor,	5 30	5 30	1 73	2 00	2 00	0 66	2	.				
,	571	25	1	4	"	1 10	1 40	0 70				5 30					
,	593	16	2	1	Rati,	2 80	2 80	5 60				2					
"	596	16	4	2	"	1 56	0 78	1 56				2					
"	598	16	4	2	"	1 10	0 55	1 10				1 10					
"	600	16	11	7	"	7 Wells 7 65	1 24	2 48				2	.				
"	602	10	2	2	Dhenkhi,	3 50	1 75	3 50				3 50					
"	608	10	4	3	Rati,	4 16	1 38	2 76				4 16					
"	605	9 5	1	1	Dhenkhi,	2 38	2 38	4 76				2					
Mean,		25		5	Lagor,	3 35	3 35	1 21	2 00	2 00	0 66	9 00			3 3		
"		14			{ Rati, Dhenkhi,	1 78	1 55	3 11				2	..		2		

\* These examples are omitted in the calculations for mean areas, &amp;c.

Provinces and Oudh, and the number of waterings required for each class of irrigated crop—1881-83—(Continued)

RABI											KHARIF					Remarks	
Safflower	Safflower & Gram	Safflower & Carrots	Gram.	Carrots	Pears.	Ons	Opium	Tobacco	Potatoes	Garlic	Garden.	Sugar	Cotton	Indian Corn.	Millet		Indigo
...	..	...	..	..	..	..	0 55	..	..	..	0 50	..	..	..	..	..	Area
...	..	...	..	..	..	..	10	..	..	..	15	..	..	..	..	..	Waterings.
...	..	...	..	..	..	..	0 20	..	..	..	..	..	..	..	..	..	Area
...	..	...	..	..	..	..	10	..	..	..	..	..	..	..	..	..	Waterings
...	..	...	..	..	..	..	7 0	..	..	..	4 6	..	..	..	..	..	Per cent area
...	..	...	..	..	..	..	10	..	..	..	15	..	..	..	..	..	Mean waterings Area 11 72
...	..	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
...	..	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Area.
...	..	...	..	..	..	..	0 18	..	..	..	..	0 51	..	..	..	..	Waterings
...	..	...	..	..	..	..	6	..	..	..	..	12	..	..	..	..	Area
...	..	...	..	..	..	..	0 46	..	0 70	..	..	1 06	..	..	..	..	Waterings
...	..	...	..	..	..	..	6	..	9	..	..	8	..	..	..	..	Area
...	..	...	..	..	..	..	0 62	..	..	..	..	..	..	..	..	..	Waterings
...	..	...	..	..	..	..	10	..	..	..	..	..	..	..	..	..	Area
...	..	...	..	..	..	..	..	..	..	..	5 20	..	..	..	..	..	Waterings
...	..	...	..	..	..	..	..	..	..	..	5	..	..	..	..	..	Area
...	..	...	..	..	..	..	1 54	..	..	..	..	..	..	..	..	..	Waterings
...	..	...	..	..	..	..	5	..	..	..	..	..	..	..	..	..	Area
...	..	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Waterings
...	..	...	..	..	..	..	2 10	..	..	..	..	..	..	..	..	..	Area
...	..	...	..	..	..	..	5	..	..	..	..	..	..	..	..	..	Waterings
...	..	...	..	..	..	..	7 3	..	1 0	..	7 9	100 0	..	..	..	..	Per cent area
...	..	...	..	..	..	..	6	..	9	..	5	10	..	..	..	..	Mean waterings Area 67 94
...	..	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
...	..	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Area
...	..	...	..	..	..	..	..	..	..	..	..	2 00	..	..	..	..	Waterings
...	..	...	..	..	..	..	..	..	..	..	..	8	..	..	..	..	Area
...	..	...	..	..	..	..	..	..	..	..	1 40	..	..	..	..	..	Waterings
...	..	...	..	..	..	..	..	..	..	..	5	..	..	..	..	..	Area
...	..	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Waterings
...	..	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Area
...	..	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Waterings.
...	..	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Area
...	..	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Waterings
...	..	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Area
...	..	...	..	..	..	..	1 13	..	..	..	..	..	..	..	..	..	Waterings
...	..	...	..	..	..	..	5	..	..	..	..	..	..	..	..	..	Area
...	..	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Waterings
...	..	...	..	..	..	..	3 2	..	..	..	3 5	100 0	..	..	..	..	Per cent area.
...	..	...	..	..	..	..	5	..	..	..	5	8	..	..	..	..	Mean waterings Area 36 85
...	..	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Total Area, 1481 37



ABSTRACT TABLE B—*Showing Area*

District.	Depth to water surface	Class	RABI			KHAIRIF.			RANI												
			Duty per			Dutr per			Wheat	Wheat & Barley	Wheat & Gram	Barley	Barley & Gram.	Barley & Peas	Safflower	Safflower & Gram	Safflower & Carrots	Gram	Carrots	Peas.	
			Well	Lift	Fair	Well	Lift	Pair													
Cawnpore,	34	Lagor,	4 15	2 68	2 57	2 13	1 41	1 35	35 5	38 7				6 3							
Hamirpur,	33	"	4 32	2 61	2 50	2 19	1 64	1 42	..	3 4	12 0										
Farakhabad,	51	"	4 21	3 15	3 10	1 45	1 45	1 45	18 7	6 4	5 37										
Mampur,	24	"	10 98	6 30	3 70				47 5	16 4	4 7	23 8	1 4						2 1	0 8	
Etah,	16	"	5 92	3 20	2 50	1 70	0 57	0 57	56 0	3 0	31 5								4 0		
Saharanpur,	17	"	2 90	2 90	2 05																
Shahjahanpur,	33	"	2 29	2 29	2 29				67 2		2 1										
Unao,	34	"	2 30	1 93	1 93				88 4												
Lucknow,	30	"	6 95	6 95	3 94	0 78	0 78	0 40	64 7			19 1									
Hardui,	25	"	3 35	3 35	1 21	2 00	2 00	0 60	90 0		3 3										
Shahjahanpur,	37	Coohe,	4 50	4 50	1 50	5 00	5 00	1 66													
Unao,	20	"	0 84	0 84	0 84																
Lucknow,	24	"	12 34	12 31	3 53																
Hardui,	30	"	7 00	7 00	2 00																
Mampur,	17	Kali,	11 58	4 77	3 94	2 31	0 85	0 75													
Aligarh,	24	"	12 92	7 28	4 50	3 02	2 12	1 02	50 3	3 5	24 0	9 6	0 4	0 1	1 6	2 0	2 0	1 4			
Muttra,	51	"	8 40	5 58	5 20				48 3	2 15	1 6	23 0	7 6	12 6		4 5					
Bulandshahr,	24	"	11 36	7 50	4 18	1 81	0 85	0 55	24 6	13 1	4 6	12 9	12 8	11 0				2 3	1 8		
Meerut,	24	"	11 91	7 23	3 62	6 17	2 76	1 36	58 0	6 3	8 9	6 9	8 0			0 2	0 6	0 3	2 0		
Muzaffarnagar,	12	"	3 53	3 53	1 77	7 95	7 95	2 42	100 0												
Bijnor,	16	"				2 40	2 40	1 32													
Moradabad,	19	"	3 91	2 93	1 63	1 17	0 82	0 42	87 5												
Bareilly,	38	"	2 90	2 63	2 63				5 0												
Farakhabad,	16	Dhenkh,	0 60	0 60	1 20																
Bijnor,	20	"	0 75	0 75	1 50																
Moradabad,	15	"	0 95	0 47	0 95																
Pilibhit,	15	"				2 80	1 40	1 86													
Shahjahanpur,	13	"	0 63	0 63	1 26																
Hardui,	10	"	2 94	2 07	4 13				60 0		20 0										
Rampur State,	21	Rati,	0 22	0 22	0 44																
Bareilly,	9	"	0 50	0 50	1 00																
Shahjahanpur,	24	"	1 74	1 16	2 32																
Hardui,	16	"	1 31	1 34	2 68				100 0												

commanded by Wells, 1881-83

PERCENTAGE.						KHARIF PERCENTAGE					Remarks.
Oats	Opium.	Tobacco.	Potatoes	Garlic	Garden	Sugar	Cotton	Indian Corn.	Millet.	Indigo	
...	77	49	40	..	29	..	81 2	.	..	18 8	The percentage in heavy black type refer merely to the class of lift opposite which they are entered, and are not general percentages of irrigation
...	88	70 5	.	...	53	80 2	19 8	.	..	...	
..	5 8	7 2	7 2	...	10	..	...	73 8	26 2	.	
...	09	0 4	0 5	...	1 5	.	...	...	...	..	
0 5	30	...	.	.	...	100 0	...	..	..	..	
..	..	..	..	...	100 0	..	...	...	..	...	
..	.	15 2	.	...	15 0	..	...	...	.	...	
...	7 0	..	.	..	4 6	.	...	.	...	..	
..	73	..	10	..	79	100 0	...	.	..	..	
.	32	..	.	.	3 5	100 0	..	..	...	...	
...	...	..	.	.	.	100 0	...	...	.	...	
..	.	..	.	.	.	.	...	...	..	...	
..	..	..	.	..	..	..	...	..	..	..	
...	...	..	.	...	...	..	...	.	.	.	
...	.	..	..	.	.	100 0	.	.	...	...	
0 05	0 2	2 7	0 6	0 55	1 00	..	100 0	...	..	...	
..	.	..	..	..	0 05	...	.	.	..	...	
0 3	.	6 1	..	..	10 5	43 7	56 3	.	..	...	
1 6	..	0 1	3 7	..	3 4	62 8	37 2	.	.	...	
..	.	...	..	...	...	100 0	...	...	.	..	
.	.	.	..	...	..	100 0	...	..	.	.	
...	.	12 5	..	.	.	100 0	.	...	...	..	
..	.	90 8	..	..	4 2	.	...	..	..	..	
...	...	.	..	..	100 0	..	...	..	...	...	
..	..	.	...	..	100 0	.	..	...	..	..	
.	.	..	...	.	100 0	..	...	..	...	...	
...	.	.	..	.	..	100 0	..	...	.	..	
...	...	..	..	...	100 0	..	...	...	..	...	
.	20 0	..	...	..	..	..	...	.	.	...	
...	.	67 0	.	..	33 0	...	...	..	..	...	
..	.	..	.	...	100 0	...	...	..	..	.	
...	...	..	.	..	100 0	.	..	..	.	..	
...	..	.	...	.	...	.	...	..	...	..	

Mean Result per pair of Cattle or Men employed.

Depth to water surface.	Class.	Labor lifting	ACRES IRRIGATED IN ONE SEASON		
			Rabi	Kharif.	Garden.
25	Kili,	Cattle,	3 43	1 12	...
30	Lagor,	..	2 58	1 00	...
30		Men,	2 34	1 66	..
15	Dhenkli,	.	*4 13	1 86	1 23
18	Rati,	..	2 68	.	1 25

\* Number of experiments and waterings insufficient.

\* Number of experiments and waterings insufficient.

TABLE C—Showing depth of watering given to various crops, and calculated loss from absorption in water-courses

District.	OBSERVATION						EXPERIMENT				CALCULATED LOSS						Remarks.	
	Number.	Crop	No of waterings required	Soil	Length of water course	Watering-Interval	Cubic feet water lifted in the day	Area irrigated in square feet	Depth of water on area in feet	Depth of damp in feet	Excess		Loss			Percentage of area lost		
											Depth.	Length of water course.	Cubic feet water	Cubic feet per foot of water-course	Area.			
CAWNPORE.	2	Wheat,	3	Dumat,	200	1	1,290	4,440	2905									
	20	"	2	"	400	1	1,140	1,498	7610		4817	50	721	14 43	2,583	172 5	Nokyanes and new water-course. Water-course new and not consolidated. First 300 feet same as 21 Mean, rejecting 20 and 22	
	21	"	3	"	300	1	2,017	15,765	1279									
	22	"	3	"	1,150	1	2,017	1,442	1 398		1 1187	800	1,612	2 015	5,772	358		
	Mean	"	"	"	512	1	1,616	5,786	0 2793		.	..	..	..	..	...		
	"	"	3	"	350	1	1,653	10,102	1636									
		Garden,	"	"	100	3	380	4,752	0799									
	533	Tobacco,	10	"	160	10 12	1,181	8,165	1446	70								
	528	"	12	"	270	12 12	1,014	7,550	1343	75								
	Mean	"	"	"	215	11 12	1,097	7,857	1396	72								
HAMIRPUR.	34	Barley,	6	Parwa,	150	1	1,139	8,286	1374	..								
	35	"	6	"	130	1	835	6,020	1387	66								
	Mean	"	6	"	140	1	987	7,153	1380	66								
	31	Tobacco,	7	"	200		683	5,705	1197									
	32	"	10	"	50	2	2,447	17,020	1437									
	33	"	10	"	250	2 20	1,285	7,551	1701		0193	61	143	2 352	951	12 6		
	47	"	5	"	256		1,145	6,590	1738		0230	67	151	2 262	1,005	15 2		
	Mean	"	8	"	189	2 20	1,390	9,216	1508									
	29	Garden,	10	Rakur,	350	.	375	2,760	1339							..	2 hours' work.	
	63	Barley,	2	Dumat,	510	1	1,184	7,200	1645									
FARUKHABAD.	66	"	2	"	440	1	608	5,100	1192									
	69	"	2	"	510	1	1,544	9,862	1565									
	72	"	2	"	450	1	1,026	4,514	2273									
	Mean	"	2	"	477	1	1,000	6,669	1635									
	78	Wheat,	4	"	560	2	1,089	6,027	1807									
	74	"	4	"	160	3	1,270	5,734	2215									
	Mean	"	4	"	360	2	1,179	5,880	2005									

TABLE C—Showing depth of watering given to various crops, and calculated loss from absorption in water-courses—(continued)

District.	OBSERVATION						EXPERIMENT				CALCULATED LOSS.						R
	Number	Crop	No of waterings required	Soil.	Length of water course	Watering Interval	Cubic feet water lifted in the day	Area irrigated in square feet.	Depth of water on area in feet.	Depth of damp in feet	Excess		Loss			Percentage of area lost	
											Depth.	Length of water course	Cubic feet water	Cubic feet per foot of water course	Area		
FARUKHABAD—(Continued)	86	Garden,	12	Matyar	160	.	343	3,483	0.984	.							
	87	"	12	"	220	..	524	3,783	1.385	..	0.193	30	72	2,428	611	16.1	
	Mean	"	12	"	190	...	433	3,633	1.192	..							
	88	Tobacco,	12	Dumat,	400	..	5	1,142	8,286	1.378	75						
	90	"	10	"	300	..		1,684	12,509	1.346	75						
	92	"	10	"	250	...		1,280	8,448	1.515	66						
	94	"	10	"	400	...		1,546	8,464	1.826	75	0.0299	50	253	5,060	1,657	19.5
	Mean	"	10	"	350	.	5	1,413	9,253	1.527	73						
MAINPURI	136	Wheat,	3	"	450	1		1,178	4,890	2.409	80						
	110	"	3	"	910	2.30		5,629	23,049	2.442	55	0.187	184	431	2,343	1,911	8.3
	123	"	3	"	800	2.30		3,603	15,362	2.346	75	0.091	74	139	1,889	619	4.0
	131	"	3	Matyar,	370	2.60		2,511	8,027	3.128	1.00	.	.	.	.	.	Damp in excess
	133	"	3	Dumat,	680	2.30		1,598	7,509	2.123	75						
	138	"	3	"	370	2.37		2,217	13,322	1.664	66						
	140	"	3	"	340	2.45		1,934	13,450	1.438	50						
	141	"	3	"	240	2.30		1,203	7,240	1.662	50						
	147	"	4	"	180	2.30		1,074	5,332	2.014	80						
	150	"	3	Matyar,	970	2.60		1,835	10,055	1.825	50				.	.	Damp deficient
	153	"	3	Dumat,	410	2.30		4,394	19,230	2.285	70						
	167	"	4	Mixed,	2,400	2.40		6,697	18,040	3.712	1.00	0.1457	1,674	2,628	1,570	11,650	64.6
	128	"	3	Dumat,	1,050	3.45		3,388	19,434	1.743	75						
	Mean	"	3	"	726	2.39		3,007	13,335	2.255	70						
	96	Gujar,	2	Sandy,	600	1		1,475	9,775	1.509	50						
	143	"	2	Dumat,	560	1		2,660	11,400	2.333	80	..	..	...	.	.	Damp in excess
		Mean	"	2	"	580	1		2,067	10,587	1.953	65					
106	"	3	"	1,060	2.20		4,294	33,107	1.297	75							
113	"	3	"	1,280	2.45		3,518	14,904	2.360	66	0.733	110	1,092	9,931	6,714	45.0	Interval in excess.
	Mean	"	3	"	1,170	2.32		3,906	24,005	1.627	70						

TABLE C—Showing depth of watering given to various crops, and calculated loss from absorption in water-courses—(continued).

District.	OBSERVATION						EXPERIMENT				CALCULATED LOSS.						Re
	Number	Crop.	No of waterings required	Soil.	Length of water course	Watering interval	Cubic feet water lifted in the day	Area irrigated in square feet	Depth of water on area in feet	Depth of dump in feet	Excess.		Loss.		Percentage of area lost.		
											Depth.	Length of water course	Cubic feet water.	Cubic feet per foot of water-course		Area.	
MAINFURT—(Continued)	100	Guchana,	2	Dumat,	1,120	1	3,718	15,362	2421	75							
	155	"	3	"	1,760	2 45	5,890	24,356	2003	55							
	117	Barley,	2	"	1,710	2 30	6,650	22,000	3023	75	0603	503	1,327	2 577	5,482	24 9	
	120	"	2	"	370	2 45	3,280	14,330	2289	80							
	160	"	3	"	1,045	2 42	5,586	31,193	1791	55							
	170	"	3	"	810	2 45	1,403	8,252	1700	70							
	173	"	2	Matyar	2,100	2 50	3,815	9,892	3857	80	1437	893	1,422	1 592	5,674	59 4	
	Mean	"	2 to 3	"	1,207	2 43	4,147	17,133	2420	72							
	166	Carrots,	10	Mixed,	660	2	1,628	11,166	1459	60							
	178	Wheat,	4	Matyar	1 960	2 60	2,974	10,934	2723	55	0450	1,188	491 8	0 414	2,164	19 8	
EXAM.	180	"	4	"	650	2 45	2,037	10,025	2032	60							
	183	"	4	Dumat,	370	2 60	2 140	6 840	3161	100	..	..	..	..	..	Dump in excess.	
	188	}	4	"	660	3 30	5,131	33,300	1541	70							
	189		"	"	"	"	"	"	"	"							
	192	"	4	"	220	3 30	2,886	5,630	5126	66							
	Mean	"	4	"	772	2 to 3 45	3,034	13,346	2273	70							
	196	{ Barley, Oats,	3 6	"	780	5 30	2,122	13,943	1522	50							
ALIGAMU	218	Wheat,	3	"	1,600	2 30	4,374	16,557	2642	75	0154	532	255	0 479	1,025	6 2	
	221	"	3	"	430	2 30	3,325	18,663	1782	80							
	259	"	3	"	1,650	2 30	13,888	12,758	2632	75	0144	582	759	1 305	3,054	5 8	
	265	{ Barley, Wheat,	2 3	"	1,500	2	14,880	54,428	2734	85	0246	432	1063	2 462	4,275	7 8 Dump in excess.	
	203	Wheat,	3	"	1,260	3 30	1,691	8,708	1942	62		..	..	..	..	Dump deficient.	
	207	"	4	Matyar	610	3 37	3,638	15,440	2356	75							
	211	"	4	"	980	3 45	3,865	30,540	1266	16	..	..	..	..	..	Dump deficient.	
	231	"	5	Dumat,	460	3 30	2,375	15,945	1490	70							
	242	{ Garlic, Wheat,	10 5	"	3 225	6 15 3 60	8,430 1,982	.. 6,924	.. 1291	75 60	..	..	..	..	..	Mixed crops.	
	268	Wheat,	3	"	1,500	3 60	4,200	13,420	3130	75	0542	432	861	2 00	3,463	25 8	
	269	"	3	"	1,000	3 60	4,853	17,990	2698	80	..	..	..	..	..	Dump in excess.	
	Mean	"	3 to 5	"	983	2 to 3 42	5,370	23,618	1806	70							

TABLE C—Showing depth of watering given to various crops, and calculated loss from absorption in water-courses—(continued)

OBSERVATION							EXPERIMENT				CALCULATED LOSS						Remarks
District	Number	Crop	No of waterings required	Soil	Length of water-course	Watering Interval	Cubic feet water lifted in the day	Area irrigated in square feet	Depth of water on area in feet	Depth of damp in feet	Excess		Loss			Percentage of area lost	
											Depth.	Length of water course.	Cubic feet water	Cubic feet per foot of water course	Area		
ALIGARH—(Continue)	Mean Wheat,	3 to 5	Dumat,	1,068	2 to 3	38	5,914	23,768	2488	75	..		..	.	.		Omitting 211 and 242
	217 Barley,	2	"	300	2	60	4,033	17,082	2361	80	.		.			..	Damp in excess
	257 "	3	"	580	2	30	1,348	4,378	3079	85	1036	140	453	3 24	2,220	50 7	Damp in excess
	200 "	3	"	420	3	30	1,642	10,600	1549	75							
	234 { "	3	"	790	3	30		15,360		70							
	{ Tobacco,	10	"	320	2		4,029	3,836	2099	1 10	0056	350	107	0 307	526	2 74	Doubtful mixed crops
	239 Barley,	4	"	300	3	35	1,270	6,834	1858	80							
	251 { Wheat,	4	"	460				5,066		80							
	{ Barley,	3	"	140	3	60	2,850	2,640	3699	60	.	...					Damp in excess
	275 { Peas,	3	"	650	3	60	3,734	26,842	1391	1 00				..			Mixed crops
MUTTRA	Mean Barley,	3	"	440	2 to 3	43	2,701	13,220	2043	79							
	255 { Kurfa,	4	"	300	2	6	1,485	12,600	1179	90							
	{ Garden,																
	279 Carrots,	5	"	600	3	20	2,295	15,207	1509	70							
	291 Barley,	3	Sandy,	520	1		1,862	7,811	2384	90							
	325 "	2	"	550	2	60	2,600	16,524	1574	1 2							
	300 Wheat,	4	Dumat,	1,020	2	67	1,565	6,336	2470	70	0778	496	493	1 00	2,913	46 0	
	312 "	4	Sandy,	120	2	60	1,143	6,504	1761	1 10	.		.	.			Damp in excess.
	307 "	4	Dumat,	500	3	45	1,800	13,024	1382	50	.		..				Damp deficient.
	309 "	3	Mixed,	570	3	45	1,247	10,047	1241	66	.		.			..	Damp deficient
BULANDSHAHAR	287 { Guchana,	5	Sandy,	180	4	30	1,484	11,037	1345	83							
	{ Wheat,	5															
	315 { Gujaj,	4	Dumat,	340	4	30	1,875	12,725	1474	1 00							
	319 Wheat,	5	"	940	4	30	2,490	8,926	2790	80	1098	416	980	2 356	5,792	64 9	
	Mean "	4 to 5	"	524	2 to 4	44	1,658	9,800	1692	80							
	346 Tobacco,	15	"	790	1		2,550	10,700	2383	66	0297	163	317	1 73	1,523	14 2	
	374 "	8	"	670	1		2,921	11,856	2464	1 00	0374	63	448	7 116	2,149	18 1	Damp in excess.
	400 "	8	Matyar,	360	1		1,738	12,000	1448	1 00							
	Mean "	10	"	607	1		2,403	11,518	2086	88							
	369 "	8	Dumat,	430	2	5	2,362	20,000	1181	60							
394 Gujaj,	4	Matyar,	750	2	45	3,693	15,000	2462	75								
381 Garden,	7	Dumat,	300	1		1,871	7,920	2362	1 5								

TABLE C—Showing depth of watering given to various crops, and calculated loss from absorption in water-courses—(continued)

District.	OBSERVATION						EXPERIMENT				CALCULATED LOSS.						Remarks.
	Number	Crop	No of waterings required	Soil	Length of water course.	Watering Interval	Cubic feet water lifted in the day	Area irrigated in square feet.	Depth of water on area in feet	Depth of damp in feet	Excess		Loss			Percentage of area lost.	
											Depth	Length of water course	Cubic feet water	Cubic feet per foot of water course	Area.		
BULANDSHAHR	386	Garden,	7	Dumat,	230	4 20	3,022	15,000	2015	1 5							
	389	"	7	"	500	4 30	4,350	24,160	1800	1 2							
	359	"	7	"	810	5 25	3,453	22,680	1523	1 4							
	Mean	"	7	"	513	4 25	3,608	20,920	1725	1 4							
MEERUT.	430	Barley,	3	Sandy,	1,400	3 60	11,160	44,800	2491	80							
	434	Potatoes,	10	Matyar	640	4 10	3,037	38,577	0787	75							
	434	Wheat,	3	"	370	2 60	2,710	10,880	2491	75							
	434	"	3	"	350	2 60	2,860	14,600	1959	66							
	439	"	3	"	3,831	2 60	3,831	11,907	3218	66	0508	233	605	2 597	2,233	18 7	{ Same water-course as 430, which was still wet. Sandy doubtful.
	441	"	3	"	1,020	2 60	4,203	15,557	2702	66	..	..			..	..	
	406	"	4	Sandy,	810	3 75	3,100	6,918	1481	75	1771	23	1225	53 27	4,521	65 3	
	412 } 414 }	" {	4 { 4 {	" {	923	3 75	2,545	39,374	2424	90							
	425	"	4	"	1,020	3 60	6,610	22,000	3004	90	0294	233	646	2 776	2,367	10 8	
	Mean	"	3 to 4	"	787	2 to 3 64	4,694	17,320	2710	75							
BAYAN BAYAN BAYAN	444	Sugar,	5	Dumat,	800	1	6,111	20,770	2942	1 0							
	449	Potatoes,	10	"	500	3 20	1,510	15,175	0995	80							
	451	Garden,	10	"	175	3 8	2,047	21,134	0908	80							
	465	Sugar,	3	"	660	1	3,819	17,578	2173	75							
	465	"	3	"	1,380	1	5,015	22,208	2258	66							
	467	"	3	"	2,030	1	4,678	13,531	3458	75	0928	673	1,255	1 866	4,963	36 7	
BILNOR.	Mean	"	3	"	1,356	1	4,504	17,772	2530	71							
	461	Garden,	10	Matyar	100	"	350	6,453	0542	80							
	463	"	10	"	60	"	114	3,460	0329	60							
	Mean	"	10	"	80		232	4,956	04681	70							
MONADABAD.	471 } 472 }	Sugar,	4	Dumat,	80	1	4,162	16,089	2587	75	0030	373	48	129	188	1 1	Damp deficient
	480	"	4	Sandy,	180	1	1,590	7,800	2039	80							
	484	"	4	"	300	1	1,379	4,000	3448	1 2	.	..	.	.	...		Damp in excess
	Mean	"	4	"	427	1	2,377	9,296	2557	91							

TABLE C—Showing depth of watering given to various crops, and calculated loss from absorption in water-courses—(continued)

District	OBSERVATION						EXPERIMENT				CALCULATED LOSS.						Remarks.	
	Number.	Crop	No of waterings required	Soil	Length of water-course	Watering.	Interval	Cubic feet water lifted in the day.	Area irrigated in square feet	Depth of water on area in feet.	Depth of damp in feet	Excess		Loss				Percentage of area lost.
												Depth	Length of water-course	Cubic feet water.	Cubic feet per foot of water-course	Area.		
MORADABAD	476	Tobacco,	30	Dumat,	270	6	3	985	15,340	0642	80							
	478	{	30	"	230	6	4	1,010	13,280	0760	70							
	30		"	250	6	3 5	997	14,310	0696	75								
	488	"	28	Dumat,	100	16	5	276	3,546	0778	66							
	497	Garden,	10	Matyar,	160	1	.	252	3,000	0840	60							
BAREILLY	490	Tobacco,	20	Dumat,	1130	10	7	1,974	14,200	1390	85	...	..	.		...	Damp in excess	
	491	"	20	"	500	10	7	2,035	14,770	1378	80							
	492	"	20	"	470	10	7	870	5,175	1681	75							
	494	"	20	"	320	12	7	708	6,080	1190	75							
	Mean	"	20	"	580	10 to 12	7	1,397	10,058	1389	79							
PILLI BHIT.	501	Sugar,	2	Sandy,	230	1		423	8,027	0527	70							
	505	"	2	Dumat,	930	1	.	1,974	7,200	2742	10							
	514	Tobacco,	20	"	300	10	6	1,984	12,995	1527	90							
	517	"	20	"	230	10	10	1,752	10,170	1728	80							
	Mean	"	20	"	265	10	8	1,868	11,582	1613	85							
SHAHJAHANPUR.	520	Garden,	20	Matyar,	120		4	360	3,706	0971	60							
	522	"	20	"	140			385	2,534	1519	60							
	524	"	20	"	150			905	7,590	1192	90							
	Mean	"	20	"	137			550	4,610	1193	70							
	552	Wheat,	3	Dumat,	400	1		1,197	5,000	2394	.							
LUCKNOW	555	"	2	Mixed,	1,300	1		1,845	16,000	1153								
	568	"	3	"	790	1		4,968	24,000	2070	.	0335	38	804	22 67	4,634	19 3	
	586	"	3	Dumat,	420	1		468	3,850	1215								
	Mean	"	3	"	752	1		2,119	12,212	1735	.							
	578	"	3	Matrar,	1,120	2	30	1,136	7,290	1558								
HAUNDI	584	"	3	Dumat	580	2		1,037	6,250	1659								
	Mean	"	3	"	850	2	30	1,086	6,770	1604								
	581	Peas,	2	"	690	2		1,321	13,500	0978	..							



TABLE C—Showing depth of watering given to various crops, and calculated loss from absorption in water-courses—(continued)

District.	OBSERVATION						EXPERIMENT				CALCULATED LOSS						Remarks
	Numbet.	Crop.	No. of waterings required.	Soil.	Length of water-course	Watering Interval	Cubic feet water lifted in the day	Area irrigated in square feet.	Depth of water on area in feet	Depth of damp in feet.	Excess		Loss			Percentage of area lost.	
											Depth	Length of water course	Cubic feet water.	Cubic feet per foot of water course	Area.		
Hannur.	590	Wheat,	2	Matyar,	505	1	1,470	5 866	2506	..	0131	193	76	398	323	5.5	
	608	"	2	Dumat.	120	1	540	2,600	2125	.							
	Mean	"	2	,	312	1	1,005	4,233	2375	.							
	588	"	2	Matyar,	510	2 30	1,298	8,425	1538	.							
	602	Opium,	5	"	130	1	975	4,055	2350	..							
	603		5	"	150	1	424	3,077	1378	..							
	605		"	5	,	150	1	424	3,077	1378	..						
	609	"	5	Dumat	500	1	498	4,100	1215	..							
	Mean	"	5	"	260	1	632	3,744	1686	.							

ABSTRACT TABLE C—Showing loss by Percolation in water-courses per foot run per day of 9 hours

Number	Soil	Excess length of water-course.	Loss per foot of water-course	Time in hours	Loss reduced to working day	No of lifts	Percentage of area lost	Remarks
33	Parwa, ..	61	2 352	7 75	2 731	1	12 6	
47	" ..	67	2 262	7 35	2 770	1	15 2	
	Mean, ..	64	..	..	2 75	1	13 9	
87	Matyar, ..	30	2 428	7 4	2 953	1	16 1	
439	" ..	233	2 597	9 75	2 381	1	18 7	
590	" ..	193	0 898	9 12	0 395	1	5 5	
178	" ..	1,188	0 414	9 3	0 410	3	19 8	
173	" ..	893	1 592	10 3	1 391	4	59 4	
	Mean, ..	507	..	..	1 506	..	29 7	Numbers 113, 234, 374, 406, 471, 472, and 568, have been omitted from this Table on account of disturbing influences which are noted in Table C
94	Dumat, ..	50	5 060	8 85	5 146	1	19 5	The loss by percolation is calculated by assuming the mean depth of each class as correct for the length of its corresponding water-courses, the excess depth of watering representing the loss for the extra length of water-course.
257	" ..	140	3 24	8 0	3 645	1	50 7	
346	" ..	183	1 73	6 7	2 324	1	14 2	The result is curiously uniform, the few inconsistent figures being easily accounted for by the varying age or condition of some water-courses
467	" ..	673	1 866	13 0	1 292	1	36 7	
22	" ..	800	2 015	8 88	2 042	2	358 0	The mean result gives a loss of 2 372 cubic feet per foot of water-course for a working day of 9 hours, but in calculation it will be safer to deduct 200 feet in every instance from the total length, and to estimate the loss at 2 0 on the balance only, as the first 200 feet of water-course near most wells is thoroughly consolidated
123	" ..	74	1 889	10 5	1 620	2	4 0	
218	" ..	532	0 479	9 5	0 475	2	6 2	
268	" ..	432	2 000	9 0	2 000	2	25 8	
300	" ..	496	1 000	7 7	1 170	2	46 0	The percentages of loss of area vary according to the crop, and those shown in this Table only represent the loss on the excess length of water-course
319	" ..	416	2 356	10 12	2 095	2	64 9	
110	" ..	184	2 343	10 7	2 000	4	8 3	
117	" ..	503	2 637	10 0	2 373	4	24 9	
167	Mixed, ..	1,674	1 570	9 45	1 495	6	64 6	
259	Dumat, ..	582	1 305	8 0	1 468	7	5 8	
265	" ..	432	2 462	8 0	2 520	8	7 8	
	Mean, ..	478	..	..	2 111	..	49 1	
425	Sandy, ..	233	2 776	10 5	2 380	2	10 8	

E—Showing Mean Depths of Waterings per Crop, and District, and average interval between each Watering

District.	WHEAT						GUJAI (WHEAT AND BARLEY)						GUCHARA (WHEAT AND GRAM)					
	Length of water course.	Depth of Watering			Depth of damp	Soil	Length of water course	Depth of Watering			Depth of damp	Soil	Length of water course	Depth of Watering			Depth of damp	Soil
		First.	Interval	Second, &c				First.	Interval	Second, &c				First.	Interval	Second, &c		
Cawnpore, ..	512	2793	..	..	..	Dumat.												
Hamirpur, ..	..	..	.	..	..	..												
Farukhabad, ..	360	..	..	2005	..	..												
Mainpuri, ..	450	2409	.	..	80	..	580	1953	..	..	65	{ Sandy, Dumat,	1,120	2421	.	..	75	Dumat
"	..	726	..	39	2255	70 { Dumat, Matyar,	1,170	..	32	1627	70	Dumat,	1,760	..	45	2003	55	"
Etah, ..	772	..	45	2273	70	{ Dumat Matyar												
Aligarh, ..	983	..	42	1806	70	{ Dumat Matyar												
Muttra, ..	..	..	..	..	..	..												
"	..	524	..	44	1692	80 { Sandy Dumat												
Bulandshahr, ..	..	..	..	..	..	..												
"	..	..	..	..	..	..	750	..	45	2462	75	Matyar						
Meerut, ..	787	..	64	2710	0 75	{ Sandy Matyar												
Muzaffarnagar, ..	..	..	..	..	..	..												
Saharanpur, ..	..	..	..	..	..	..												
Bynor, ..	..	..	..	..	..	..												
Moradabad, ..	..	..	..	..	..	..												
Rampur, ..	..	..	..	..	..	..												
Bareilly, ..	..	..	..	..	..	..												
Pilibhit, ..	..	..	..	..	..	..												
Shahjahanpur, ..	..	..	..	..	..	..												
Lucknow, ..	752	1735	..	..	..	Dumat												
"	..	850	..	30	1604	.. { Dumat Matyar												
Hardoi, ..	312	2375	..	..	..	{ Dumat Matyar												
"	..	510	..	30	1538	.. Matyar												
Mean, ..	504	2366	..	..	80	Mixed,	580	1953	..	..	65	{ Sandy, Dumat,	1,120	2421	.	..	75	Dumat.
"	..	689	..	42	1985	70	960	..	38	2045	72	{ Dumat, Matyar,	1,760	..	45	2003	55	..

